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# Report on the Construction Industry Collaborations Workshop

United States Department of Commerce
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# Report on the Construction Industry Collaborations Workshop

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By:
CIVIL ENGINEERING RESEARCH FOUNDATION
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# REPORT on the
# CONSTRUCTION INDUSTRY COLLABORATIONS WORKSHOP

**Civil Engineering Research Foundation**
**November 1996**

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## APPENDICES

## ACRONYMS

| | |
|---|---|
| APWA | American Public Works Association |
| ASCE | American Society of Civil Engineers |
| AWTTS | Advanced Waterfront Technology Test Site |
| ATLSS | Center of Advanced Technology for Large Structural Systems |
| ATP | Advanced Technology Program |
| BFRL | Building and Fire Research Laboratory |
| C&B Subcommittee | Subcommittee on Construction and Building, National Science and Technology Council |
| CALTRANS | California Department of Transportation |
| CAT | Caterpillar Inc. |
| CEITEC | CE Innovative Technology Evaluation Center |
| CEO | Chief Executive Officer |
| CERF | Civil Engineering Research Foundation |
| CERL | Construction Engineering Research Laboratories |
| CI | Composites Institute |
| COE | U.S. Army Corps of Engineers |
| COE-TEC | COE-Topographic Engineering Center |
| CONMAT | High Performance Construction Materials and Systems Council |
| CPAR | Construction Productivity Advancement Research program |
| CPAR-CRDA | CPAR-Cooperative Research and Development Agreement |
| CRADA | Cooperation Research and Development Agreement |
| CRREL | Cold Regions Research and Engineering Laboratory |
| DOD | U.S. Department of Defense |
| DOE | U.S. Department of Energy |
| DOT | U.S. Department of Transportation |
| FERF | Frost Effects Research Facility |
| FHWA | Federal Highway Administration |
| FOIA | Freedom of Information Act |
| FPL | Forest Products Laboratory |
| FRP | Fiber-Reinforced Polymer |
| GDP | Gross Domestic Product |
| GPS | Global Positioning System |
| GSA | General Services Administration |
| HITEC | Highway Innovative Technology Evaluation Center |
| HUD | U.S. Department of Housing and Urban Development |
| IBACOS | Integrated Building and Construction Solutions |
| ICBO | International Conference of Building Officials |
| IERF | Ice Engineering Research Facility |
| ISTEA | Intermodal Surface Transportation Efficiency Act |
| MDA | Market Development Alliance |
| NAHB | National Association of Home Builders |

| | |
|---|---|
| NAPA | National Asphalt Pavement Association |
| NFESC | Naval Facilities Engineering Service Center |
| NIOSH | National Institute for Occupational Safety and Health |
| NIST | National Institute of Standards and Technology |
| NREL | National Renewable Energy Laboratory |
| NSF | National Science Foundation |
| R&D | Research and Development |
| SBIR | Small Business Innovative Research |
| SHPB | Split Hopkinson Pressure Bar |
| TRP | Technology Reinvestment Project |
| TTPO | Trade, Technical and Professional Organization |
| USDA | U.S. Department of Agriculture |
| WES | U.S. Army Waterways Experiment Station |

## Executive Summary

The Subcommittee on Construction and Building of the President's National Science and Technology Council and the U.S. Army Corps of Engineers sponsored the Construction Industry Collaborations Workshop in April 1996 as a critical first step in identifying ways to improve collaborative mechanisms between the public and private sectors. The Workshop was attended by over 120 key construction industry, government, and academic research managers who spent one and a half days developing strategies to improve and foster new partnerships among industry, academia, and the Federal government. This report provides a summary and the results of the Workshop, and is intended to encourage involvement of organizations not in attendance as well as to maintain the involvement of Workshop participants in furthering collaborative efforts.

While numerous unique construction industry resources and capabilities exist within the Federal government system, private industry often views the task of developing formal collaborative relationships with government as complicated or cumbersome. In fact, there are many mechanisms for collaboration with the government that range in scope and complexity. In today's business environment of increased construction needs coupled with limited facilities and resources, it is critical to make use of existing resources through the effective sharing of laboratory facilities, expertise, and other specialized assets. The Construction Industry Collaborations Workshop was an attempt to explore how these potential partnering relationships can be strengthened and expanded. The goals of the Workshop were to disseminate information and to construct new strategies that make effective collaboration a more plausible alternative for the entire construction community, rather than to develop specific partnering arrangements among the limited organizations in attendance.

**In today's business environment ...it is critical to make use of existing resources through the effective sharing of laboratory facilities, expertise, and other specialized assets.**

### Format

The Workshop was intended to support the National Construction Goals by identifying specific needs, opportunities, and mechanisms for collaborative research, development, and commercialization. The key objectives of the Workshop were to:

- Inform and educate participants about current mechanisms and processes for collaboration
- Determine means to improve collaborative mechanisms among industry, academia, and government
- Inform and educate participants about the programs, capabilities, and facilities of government agencies
- Explore critical issue areas of significance that would benefit from collaborative

efforts

- Provide participants the opportunity to voice their needs and concerns to potential partners.

The Workshop accomplished these objectives through plenary sessions, small group discussions and brainstorming sessions, and informal one-on-one discussions. Exhibit displays highlighting Federal agencies' activities, capabilities, and facilities in the construction and design fields were also a key part of the Workshop.

**Duplication in R&D should be minimized to the extent possible in order to maximize return on both the private sector's and public sector's investment.**

A keynote address by Dr. Mary Good, Under Secretary for Technology, Department of Commerce, and plenary sessions on the National Construction Goals and Federal government capabilities provided participants with context and background on the government's interest and involvement in collaborations with industry and in construction activities. Participants also heard case studies of successful collaborations presented by the industry partners. These presentations highlighted the benefits of public-private sector collaboration, barriers overcome, and any roadblocks that remained. A plenary session on intellectual property rights provided some new insights and answered participants' questions relating to contractual and legal agreements among collaborators.

Discussions and brainstorming sessions were held among small groups to inform participants about different types of partnering mechanisms; to discuss the strengths and weaknesses of each mechanism; to identify potential ways of improving such collaborations; and to generate ideas for new collaborative mechanisms. Breakout sessions were also held to determine the role(s) that the government should play in collaboration with the construction industry to fill existing gaps in the areas of research and pre-commercial technology development, technology demonstration and deployment, information dissemination, and cross-industry communication.

**Action Items and Recommendations**

The Workshop participants utilized the ideas generated during these small group sessions to develop a set of action items to be taken by both industry and government to continue the active and productive dialogue fostered at the Workshop and to facilitate future partnering activities. These actions include modifying the current Cooperative Research and Development Agreement (CRADA) protocols to be more uniform throughout the Federal government, yet flexible and responsive to the needs of industry, academia, and government. A handbook outlining the CRADA process and specific options for addressing issues such as intellectual property and liability should also be developed in order to educate industry on the details of working with the government and thus to foster collaboration.

The participants recommended that the government develop a systematic mechanism for assessing its research and development (R&D) activities and funding levels so that

they are concurrent with national needs. Federal government, industry, and academic resources should be coordinated to best meet these needs. In this time of limited budgets, duplication in R&D should be minimized to the extent possible in order to maximize return on both the private sector's and public sector's investment. The government and private sector should continue to develop effective partnerships in areas of mutual technology interest and requirements. Additionally, the government should promote technological growth and long-term investment in construction by strengthening its efforts to work with the private sector in demonstrating innovative technologies.

**The government and private sector should continue to develop effective partnerships in areas of mutual technology interest and requirements.**

Industry and academia are generally unaware of the quality and extent of the government resources available to them. A readily accessible, comprehensive catalog of Federal government construction-related facilities, capabilities, and agencies would help to educate the private sector on the different types of resources that can be utilized in collaboration with the government. Forums such as the Construction Industry Collaborations Workshop should continue to be conducted and should be expanded to include other industry sectors, such as state and local governments, in order to stimulate and facilitate beneficial construction-related collaboration among industry, academia, and government.

# 1. Introduction: Why Hold a Workshop on Collaboration?

This report presents the results of a workshop held to document and expand the opportunities for active collaboration between the design and construction industry and the Federal government. One of the implicit questions underlying the decision to hold the conference is why the two parties have not collaborated more extensively to date. There are numerous construction-related resources available in the Federal government that are not duplicated in the private sector. Nonetheless, industry may not be fully aware of these capabilities or of the opportunities available for collaboration with government. Further, private industry has too often viewed the effort of developing formal collaborative relationships with government as being complicated. In fact, collaborations can range in complexity. In an age of heightened construction needs coupled with finite facilities and resources, it is critical that all potential partnering relationships be supported and nurtured. The Construction Industry Collaborations Workshop was an attempt to both inform industry about potential collaborative relationships and, most importantly, to explore how these relationships can be strengthened and expanded.

**There are numerous construction-related resources available in the Federal government that are not duplicated in the private sector.**

Over 120 key industry, government, and academic research managers met for one and a half days on April 2-3, 1996, to identify ways to improve collaborative mechanisms between the public and private sectors. The Workshop, held at the Sheraton National Hotel in Arlington, Virginia, was sponsored by the Subcommittee on Construction and Building, Committee on Civilian Industrial Technology (recently renamed the Committee on Technological Innovation), National Science and Technology Council and the U.S. Army Corps of Engineers. It was an explicit attempt by the Federal government to reach out to the private sector.

**Background**

The United States has had a fifty year unwavering commitment to maintaining the national science and technology base through research and development. Over this period, however, as times have changed, our government's involvement in technology development has evolved from the more passive "spin-off" approach prevalent throughout the Cold War era to the development of specific programs designed to encourage government and private sector partnerships, particularly in pre-competitive and emerging technologies. In today's competitive global marketplace, relying solely on government investment or solely on private sector investment in research and technology development and commercialization may not be sufficient to maintain and secure our nation's future technological strength. As a key element of its technology policy for economic growth, the Administration has established and expanded a number of programs in tandem with the private sector that are designed to support emerging technologies. While these technology partnerships with the private sector have been viewed by some as a form of industrial subsidy, these efforts have

helped to ensure U.S. technological leadership and a strong economic future by supporting necessary programs that were too large or broad-based to be conducted by industry alone. While commitments of both the private and public sectors to continued technological excellence are needed, these commitments should be built upon making efficient use of existing resources through effective sharing of laboratory facilities, expertise, and other specialized assets. This is the context in which this Workshop was conceived. Dr. Mary Good, Under Secretary for Technology, Department of Commerce, spoke to these issues in her keynote address to Workshop participants.

The importance of the construction industry to the nation's economy is manifest. In 1995, the total construction market in the United States (including new construction, repair, retrofit, and renovation) accounted for approximately $900 billion, or about 13 percent of the GDP -- making the design and construction industry the nation's largest manufacturing industry. The construction industry employs over ten million individuals, and over 60 percent of our national wealth is invested in constructed facilities, such as homes, factories, offices, hospitals, roads, and bridges. Accordingly, the durability of constructed facilities directly affects the productivity of all U.S. industries and everyone's quality of life.

Yet, the construction industry has been very conservative in its investment strategy. Total construction-related R&D, including both public and private sector investment, represents less than 0.5 percent of total sales. This compares with a national average of 3.7 percent for mature U.S. industries, and with as much as 5, 6, or even 7 percent for such areas as telecommunications, aerospace, and biomedical research. Moreover, foreign construction R&D investment is often significantly greater than our nation's commitment to date.

Over two years ago, the Federal government explicitly recognized the need to change this investment paradigm. The Subcommittee on Construction and Building (also called the C&B Subcommittee) was established, with its mission to "enhance the competitiveness of U.S. industry, public and worker safety and environmental quality through research and development, in cooperation with U.S. industry, labor, and academia, for improvement of the life-cycle performance of constructed facilities."

**...the construction industry has been very conservative in its investment strategy.**

One of the Subcommittee's functions is to coordinate Federal R&D activities in an effort to avoid duplication. Sixteen agencies are currently represented in its membership, including those who perform research, such as the National Institute for Standards and Technology, National Institute for Occupational Safety and Health, and the Department of Energy; those who fund research in academia, such as the National Science Foundation; those who construct and operate facilities, such as the Department of Veterans Affairs and the General Services Administration; and those who regulate various aspects of the industry, such as Occupational Safety and Health Administration and the Environmental Protection Agency. The C&B Subcommittee also addresses an Administration goal to forge partnerships

with industry to strengthen U.S. industrial competitiveness.

The National Construction Goals, proposed by the C&B Subcommittee, focus on two priority thrust areas: better constructed facilities and the health and safety of the occupants and the construction workforce, and were defined to serve as the core of research, development, and deployment in the construction field. These Goals are:

- 50 percent reduction in delivery time
- 50 percent reduction in operation, maintenance, and energy costs
- 30 percent increase in productivity and comfort
- 50 percent fewer occupant-related illnesses and injuries
- 50 percent less waste and pollution
- 50 percent more durability and flexibility and
- 50 percent reduction in construction work illnesses and injuries.

**A major tenet of the Workshop was to develop specific actions that would facilitate partnering activities.**

The importance of each of these goals varies widely by sector; accordingly, industry sector-specific implementation actions are being led by different industry organizations. The Federal government has recognized the need to work with industry and has developed a strategy to do so. Further information on these goals and an identification of technology needs and barrier removal necessary to meet the goals are presented in *Construction and Building: Federal Research and Development in Support of the U.S. Construction Industry*, published by the C&B Subcommittee. The Construction Industry Collaborations Workshop was intended to support achievement of the National Construction Goals by identifying specific needs, opportunities, and mechanisms for collaborative research, development, and commercialization.

**Workshop Process**

The key objectives of the Construction Industry Collaborations Workshop were to:

- Inform and educate participants about current mechanisms and processes for collaboration
- Determine means to improve collaborative mechanisms among industry, academia, and government
- Inform and educate participants about the programs, capabilities, and facilities of Federal government agencies
- Explore critical issue areas of significance that would benefit from collaborative efforts
- Provide participants the opportunity to voice their needs and concerns to potential partners.

A major tenet of the Workshop was to develop specific actions that would facilitate partnering activities. Since only a limited number of individuals were able to attend the Workshop itself, however, the event was not organized as a means to develop exclusive, specific relationships with only those individual firms, university departments, and

agencies in attendance. Rather, the goal was to disseminate information and construct new strategies that make effective collaboration a more plausible alternative for the entire construction community. Specific action items designed to further this objective are presented in Section 7 of this report.

The Construction Industry Collaborations Workshop was designed as a forum where the public and private sectors could come together to learn about collaboration opportunities and to develop strategies for improving and fostering collaboration. The planning for the Workshop was conducted by a steering committee composed of representatives from various sectors of the construction industry and the Federal government. The steering committee and Workshop planning was coordinated and facilitated by the Civil Engineering Research Foundation (CERF). The goal of the planning effort was to develop an appropriate forum at which both the private sector's and public sector's needs and objectives would be met. Industry representatives stated that they wanted to learn about the collaboration mechanisms and government resources available to them, and also wanted to discuss concerns and suggest solutions in a forum with appropriate government representatives. Government objectives were to inform and educate industry on collaboration mechanisms and Federal facilities, and also, most importantly, to learn what actions industry would like the government to take in order to improve and stimulate collaboration between the two sectors and to make the government a better partner. The Workshop accomplished these objectives through informative plenary sessions, small group discussions and brainstorming sessions, and informal one-on-one discussions. Fifteen exhibit displays highlighting Federal agencies' activities, capabilities, and facilities in the construction and design fields were also a key part of the Workshop. Displays were presented by a wide range of agencies, including:

- Air Force, Wright Laboratories/FIVCF
- Army Corps of Engineers
- Department of Agriculture Forest Service
- Department of Commerce
- Department of Energy
- Department of Labor
- Department of Transportation
- Department of Veterans Affairs
- Environmental Protection Agency
- National Institute for Occupational Safety and Health Centers for Disease Control
- National Science Foundation
- Naval Facilities Engineering Service
- Center and the Small Business Administration.

A list of these exhibiting agencies with contact information is found in Appendix B.

This report provides a summary of the Workshop plenary sessions and the results from the small group sessions on collaborative mechanisms and opportunities for partnerships, and is organized by Workshop topic area.

## 2. Under-utilized Assets: Resources for the Construction Community

This section provides some samples of the construction-related research facilities that exist within the Federal government, based on the Workshop presentation by Donald Leverenz, Assistant Director of Research and Development (Military Programs), U.S. Army Corps of Engineers. Many of the facilities are unique, not widely known to industry, and would be cost prohibitive for industry to replicate. Their use should greatly increase the capabilities of private industry and encourage collaborations between the public and private sector.

**This year WES will put into operation the world's largest and most technically diverse Civil Engineering Centrifuge.**

*Department of Defense:*

Within the Department of Defense, the Army Corps of Engineers, the Navy, and the Air Force all have construction-related research facilities. The research thrusts of the Army Corps of Engineers include corrosion and materials, design and construction, pavements, energy conservation, facilities operation and maintenance, and coastal engineering. Three Corps laboratories have unparalleled construction-related research and testing facilities.

The Army's ***Waterways Experiment Station (WES)***, located in Vicksburg, Mississippi, is the principal research, testing, and development facility of the Army Corps of Engineers. WES has six distinct laboratories focusing on hydraulics, coastal engineering, geotechnical engineering, structures, environmental engineering, and information technology. This year WES will put into operation the ***world's largest and most technically diverse Civil Engineering Centrifuge***. The centrifuge will have a 6.5 meter arm capable of accelerating a 2 ton load to 350 g's, or a 9 ton load to 150 g's. The test samples are placed on a 1.2 meter by 1.2 meter platform and can be subjected to a wide range of climatic conditions, including freezing temperatures and high vacuums. The centrifuge can be used to solve a vast array of geotechnical, structural, hydraulic, coastal, and environmental engineering problems. For example, it can take a .3 meter model of an earthen structure such as a dam, and by accelerating it to 100 g's, accurately simulate the performance of a 30 meter high structure. A 30 year ground water diffusion study can be completed in 1 day within the high gravity of the centrifuge.

The ***Directional Spectral Wave Generator*** is a computer-controlled facility that can reproduce waves of varying height, period, and direction in a laboratory environment. The wave generator enables WES to conduct research addressing the effects of both natural- and explosives-generated waves on coastal structures. The Corps' ***Coastal Field Research Facility***, also part of WES, is the largest facility of its type in the world. The facility is located on 692,000 meters$^2$ at Duck, North Carolina, and includes a 561 meter research pier, a laboratory, and data collection equipment for monitoring coastal and ocean processes. National and

international research projects are conducted at this unique facility each year.

The ***Construction Engineering Research Laboratories (CERL)***, located in Champaign, Illinois, is the main Army laboratory for facilities infrastructure and environmental research to support sustainable installations. CERL operates the ***country's largest Tri-axial Earthquake and Shock Simulator***. The shake table has a (0.3) meter maximum displacement and can provide a 60,100 kg ton structural model with a seismic load equivalent to an 8 on the Richter scale. In the bi-axial mode, it can provide a 5,400 kg load with a vertical shock of 50 g's and a horizontal shock of 25 g's. The simulator can be used in several testing functions, including the evaluation of building shock isolation systems, the study of the behavior of structural building models and components in seismic environments, and the evaluation of the shock survivability of mechanical equipment.

The Army's ***Cold Region Research and Engineering Laboratory (CRREL)***, in Hanover, New Hampshire, operates the unique ***Frost Effects Research Facility (FERF)***. FERF is a 55.5 meters long by 31 meters wide refrigerated facility used for full-scale testing of the effects of freeze/thaw conditions on pavements, soils, structures, vehicles, equipment, etc. The FERF has 12 test basins each 6.4 meters wide (approximately the width of a standard road lane); four of the test sections are 7.6 meters long and 2.4 meters deep to evaluate subsurface effects. These 12 chambers can be used separately for small experiments, or combined in a variety of ways to accommodate larger projects. CRREL also operates the ***Ice Engineering Research Facility (IERF)*** in which it conducts large-scale tests on equipment and structures in river and sea ice environments. The facility consists of three test areas, a test basin, a cold research area, and a flume. The test basin can simulate both fresh and salt water conditions and can be operated at temperatures between 18° C and -23° C. The basin is 9.1 meters wide, 2.4 meters deep, and 66.6 meters long to allow for large-scale studies of offshore structures, locks and dams, and bridges and piers in severe winter conditions. The research area is a large refrigerated room with an 24 by 48 meters clear span where large-scale physical models of sections of rivers and lakes can be built and operated in simulated winter conditions. The research flume is 66.6 meters long with a .6 meter by 1.2 meter cross section and has a flow capacity of .04 meter$^3$/sec.

**CRREL also operates the Ice Engineering Research Facility (IERF) in which it conducts large-scale tests on equipment and structures in river and sea ice environments.**

The Navy and Air Force construction-related research areas include fire fighting, ocean and waterfront facilities and operations, and critical air base facilities and recovery. The Naval Facilities Engineering Service Center (NFESC) at Port Heuneme, California, houses the ***Advanced Waterfront Technology Test Site (AWTTS)***. This facility allows testing and evaluation of advanced materials systems and methods for waterfront construction, repair, and upgrade. Associated with this test site is a natural seawater corrosion laboratory which enables

engineers to study the corrosion resistance and durability of materials both in the lab and in the harbor.

The Air Force's Air Base Technology Branch at Tyndall Air Force Base uses its ***Split Hopkinson Pressure Bar (SHPB)*** to test the dynamic properties of materials at strain rates of 10 to $10^4$/sec. The Air Force uses SHPB and its other facilities to study properties of materials associated with structural response near exploding conventional weapons. Strain gauges are located on the long bar to measure incident and reflected strains, while strain gauges on the short bar measure transmitted strains.

*Department of Commerce: National Institute of Standards and Technology:*

The National Institute of Standards and Technology (NIST) operates the ***Building and Fire Research Laboratory (BFRL)*** and conducts research in the areas of construction materials performance, construction robotics and automation, earthquake and wind hazard reduction, fire protection and safety, and advanced building environmental systems. Its ***Tri-Directional Test Facility*** is a computer-controlled facility that can apply cyclic loads in three directions simultaneously to full-scale structural components or assemblages. The facility is ***one of the largest such facilities in the world***, and is capable of testing specimens up to 3.3 meters high and 3 meters in length or width at loads of up to 2,000 kN in the vertical and 900 kN in each of the two horizontal directions. The six degrees of freedom allow for translations and rotations along three orthogonal axes. The facility is used to examine the strength of structural components under the application of a variety of loading phenomena, such as winds or earthquakes.

As the Federal government's principal fire research laboratory, BFRL maintains some of the ***country's best and most extensive fire testing facilities***. In its ***Large Burn Facility***, smoke abatement equipment permits large fire tests to be conducted safely without polluting the environment. A substantial portion of the large-scale fire experiments are performed in a specially equipped 27 meter by 57 meter fire research building. A large overhead hood collects the exhaust products, and is calibrated to measure the release rates of heat, smoke and other products of the fire. The room's fire environment can then be characterized in terms of temperature and pressure gradients and the spatial distribution of thermal flux, gaseous combustion products, and smoke. Suppression systems can also be evaluated in the burn room or under the hood.

*Department of Transportation:*

The Federal Highway Administration (FHWA) conducts and facilitates research in the areas of bridges, pavements, geotechnology, high-performance materials, nondestructive testing and monitoring, automation and robotics for renewal engineering, and the reduction of intermodal hazards. The ***Pavement Testing Facility*** at the FHWA's Turner-Fairbank Highway Research Center has room for the construction of 24 full-scale test pavement

**The Accelerated Loading Facility has the capability of simulating 20 years of traffic loading in six months or less.**

sections, allowing researchers the capability to monitor their behavior under controlled loading conditions. ***The first of its kind in North America, the Accelerated Loading Facility*** is a 29 meter long structural frame containing a moving wheel assembly that can apply loads ranging from 44.5 to 100kN, and can travel at 18.5 km/h over the 9.8 meter test pavement section. It has the capability of simulating 20 years of traffic loading in six months or less.

The ***FHWA Structures Laboratories*** consist of two facilities for conducting research on structural reliability and integrity of highway bridges and bridge members. Both facilities accommodate static and fatigue testing. The original laboratory has a 12.2 meter by 3.7 meter load floor containing threaded tie-downs for holding loading fixtures. An MTS hydraulic distribution system supplies a variety of load jacks plus 3 stand-alone load frames. A new lab was completed in 1984 and has a 55.2 meter by 15.5 meter load floor and is instrumented to provide the unique capability of monitoring the response of the floor during experimental loadings.

*National Science Foundation:*

The National Science Foundation (NSF) funds research concerning materials and structures deterioration, assessment technologies, renewal engineering of infrastructure, and institutional effectiveness and productivity. NSF collaborates with many partners in industry at its ***Center of Advanced Technology for Large Structural Systems (ATLSS)*** at Lehigh University. The ***Multidirectional Experimental Laboratory*** at ATLSS is equipped with multidirectional reaction walls of up to 15.2 meter, and can test three-dimensional static, fatigue, and pseudo-dynamic loading on large-scale structural components.

*Department of Energy:*

The Office of Building Technology at the Department of Energy (DOE) is responsible for research on energy performance of buildings, including thermal insulation systems, windows, and heating and cooling equipment. Other research thrusts include renewable energy and energy-optimizing design tools. The ***Infrared Thermographic Lab at its Berkeley Laboratories*** includes a high-resolution, infrared (IR) imaging camera, coupled with an environmental chamber to hold samples for testing. The camera system is portable and can measure surface temperatures that can be correlated to various heat loss or gain parameters. The IR camera is useful for assessing heat loss from existing buildings in the field, as well as from building components and appliances in the laboratory.

The ***large-scale Climate Simulator*** is the centerpiece test facility at the Department of Energy's ***Building Technology Center at the Oak Ridge National Laboratory***. The simulator has been used to evaluate roof system performance under various temperature, humidity, and sun exposure conditions. The Building Technology Center also has a guarded "hot box" capable of testing full-size building components and

**The large-scale Climate Simulator is the centerpiece test facility at the Department of Energy.**

many other test facilities for evaluating the energy efficiency and performance of building systems, materials, and mechanical systems.

*Department of Agriculture:*

The Department of Agriculture Forest Service's ***Forest Products Laboratory (FPL)*** conducts research on wood processing technologies, wood performance characteristics in housing, test procedures and criteria for codes and standards, and the economic feasibility and impact of wood products. The FPL consists of a 3-dimensional test frame, an engineering mechanics laboratory with a one million pound universal test machine, fire test equipment, and a finish exposure site for the testing and evaluation of wood products. The ***Engineered Mechanics Lab*** is capable of complete testing services for physical and environmental research, and has test machines for the tension testing of structural lumber. The tests conducted here serve as the basis for U.S. and international building and grading standards.

*Department of Health and Human Services:*

The National Institute for Occupational Safety and Health (NIOSH) conducts workplace hazard assessments, workplace hazard reduction planning, worker education and training, and research on control technology for worker exposure. The ***NIOSH laboratory*** has a number of inhalation exposure chambers to support its work in setting safe working standards. For examples, the laboratory has seven 5-$m^3$ inhalation exposure chambers, eight 1/2-$m^3$ chambers, and two 10-$m^3$ walk-in chambers, joined by a common side and entered through a ventilated airlock. These chambers are supplied by two separate systems with cleaned, conditioned air, which is re-purified with high-efficiency charcoal filters downstream of the chambers. NIOSH engineers also develop portable instrumentation, such as analytical equipment mounted on the deck of an asphalt paving machine, to assist with the development and evaluation of new technologies to reduce worker exposures to hazardous contaminants. In one application, a unique tracer gas analysis technique, formerly found only in sophisticated laboratory environments, is used to evaluate prototype control technologies at a road construction project.

The facilities highlighted here are only a sampling of the various types of research facilities that are available within the Federal government to support the design and construction industry. Additional technical details on the facilities and information about specific opportunities for partnering are available from the individual agencies, and suggested contacts are listed in Appendix C.

## 3. Success Stories: Case Studies of Successful Collaborations

Despite the perception by some that collaboration between the public and private sectors is fraught with problems, many significant collaborations have been completed within the past few years. This section reviews a number of them, reflecting a great range in research topics, potential markets, government collaborators, and industry partners. The following case studies of successful public-private sector collaborations were presented at the Workshop by the industry partners involved. These presentations highlighted the benefits of public-private sector collaboration, barriers overcome, and any roadblocks that remained. The audience was given the opportunity to ask specific questions at the end of the presentations.

### 3.1 Composites Institute Market Development Alliance: Market Development Success Story

The Composites Institute (CI) is the world's largest trade and professional organization serving the fiber-reinforced polymer (FRP) composites industry. CI has been actively involved in market development at an industry level for more than five years, focusing on R&D and pre-competitive development of structural applications for FRP composites in construction and civil infrastructure under its Market Development Alliance (MDA).

When this process began in 1989, a strategic decision was taken that development "partnerships" would be established between *all* parties who will be affected by successful development of composites technology.

**The first-generation benefits to composite fabricators and the construction industry are already apparent.**

CI spent the first two years seeking out cooperative development partnerships with government, academia and other industry groups. A good example of the power and efficiency of inter-segment collaboration is the MDA project, "*Development and Demonstration of Optimized Composite Structurals.*" This program is organized under the U.S. Army Corps of Engineers Construction Productivity Advancement Research (CPAR) program, bringing together the Corps' CERL, U.S. Navy/NFESC, American Society of Civil Engineers (ASCE), the Constructed Facilities Center of West Virginia University and CI's MDA representing the U.S. FRP composites industry. The task of developing, demonstrating and commercializing such new structural technology for civil engineering was too large a challenge for any single organization. By creating a "team" of interested parties whose constituencies stand to benefit by successful development and deployment of the technology, the odds of success were dramatically increased and the resources required were significantly decreased.

The first-generation benefits to composite fabricators and the construction industry are already apparent. The research team has developed a new fiber reinforcing architecture which increases load bearing capacity of a conventional composite "I" wide-flange section by more than 53% using standard tooling. New geometries for primary and secondary structurals are being developed as well as all-composites bridge

decks. The potentials are enormous!

Intellectual property rights are addressed by giving project participants royalty-free licenses to practice any new technology developed by the project. Non-participants will be able to license the technology with proceeds being distributed among the project participants.

Technology deployment and commercialization issues are addressed early in the process by involving representatives of the shareholder community. Trade, technical and professional organizations (TTPOs) representing the end-user/practitioner communities are responsible for assisting and providing guidance to assure that the new technology is widely publicized and demonstrated using their existing organizational structures.

Other major development programs have been organized, including waterfront piling structures, repair of deteriorated concrete structures, "smart" particle tagged composites, concrete reinforcement, and multiple-phase material hybrids (timber, steel, aluminum, etc.).

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### 3.2 Case Study of a HITEC Client: SEAWARD International, Inc.

Seaward International, Inc., a worldwide leader in elastomer and plastics technology for over twenty years, has traditionally focused on the marine industry, manufacturing fenders and buoys.

The company diversified into the plastic material industry approximately three years ago, manufacturing SEAPILE and SEATIMBER Composite Marine Piling and Timber. The objective was to create an engineered product for a wide range of applications, superior in physical and performance characteristics to traditional materials. A further objective was to provide economical alternatives to the use of increasingly restricted chemically-treated wood products. Current applications include: fender piles, dolphins, docks and pier fender systems, light structural piles, navigation aids and markers. Future applications include: bridge pier protection and fendering, sign posts, guard rail systems, noise barriers, utility poles, railroad crossties and fence systems.

Seaward's collaborative efforts combine industry, government, academia, and professional associations. Specifically, their relationship with Highway Innovative Technology Evaluation Center (HITEC) has enabled them leverage industry knowledge through a network of leaders in the transportation industry. Benefits of

collaboration include: technical expertise, market knowledge and established credibility throughout new markets.

Capital investment, and technological and engineering issues were some of the major barriers overcome. Seaward developed new manufacturing technology, built a plant and debugged production, as well as developed detailed technical information which gained widespread acceptance.

Roadblocks that still remain include a new set of capital investment issues, engineering issues, production capacity, which is not currently sufficient to meet the marine market demands, and product acceptance into new markets. With each entry into a new market with a new product, additional barriers and product acceptance issues will arise.

For additional information please contact:
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Seaward International, Inc.
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Fax: (540) 667-7987

### 3.3 "Autonomous Construction Vehicle Navigation and Automation": U.S. Army COE-TEC and Caterpillar Inc.

The objective of the project was to develop a system to position and track the earthmoving machines during their normal construction activity. The positioning system was based on Global Positioning System (GPS) software developed by the Corps of Engineers- Topographic Engineering Center (COE-TEC) that was then integrated with software and hardware developed by Caterpillar Inc. Computer Aided Drafting and Design (CADD) tools were integrated with machine controls to aid in the planning and execution of the construction site earthworks.

This partnership arose out of mutual requirements and very well matched capabilities of each partner. Both Caterpillar and the COE have customers that use a multiplicity of GPS receivers for surveying and machine monitoring. The COE needed to match the GPS software to the customer preference and CAT also needed to be compatible with construction site instrumentation already on location. It was cost prohibitive to work with every GPS manufacturer, and support the real-time kinematic software development for the various receivers. The COE plan to develop the On-The-Fly (OTF) positioning software and the availability of the source code at the end of the Construction Productivity Advancement Research-Cooperative Research and Development Agreement (CPAR-CRDA) led to a workable agreement between COE-TEC and Caterpillar Inc. The agreement was left flexible so as to adapt to changing conditions and newly arising requirements. As the commercialization plan developed, the technical direction was modified by mutual consent to accommodate these changes.

The resulting product matches the current state of implementation and development and further supports the evolving customer needs.

**Intellectual property rights were the major bone of contention.**

The CPAR-CRDA was entered into by:
Caterpillar Inc.
Research Department
Technical Center
Peoria, IL 61656
Contact: Adam J. Gudat

U.S. Army Corps of Engineers
Topographic Engineering Center
Bldg 2592, Leaf & Telegraph Road
Fort Belvoir, VA 22060
Contact: Jeffrey C. Walker

The research and development plan and the responsibilities were easily agreed upon. Fulfilling all of the CPAR-CRDA boilerplate requirements was another matter. Intellectual property rights, and rights to technologies that had already been developed or were being developed under separate funds, were the major bone of contention. It took months of negotiations and a lawyer's interpretation of every statement and phrase to finally obtain a mutually beneficial CPAR-CRDA.

### 3.4 HOMEBASE: A National Home Building Industry Technology Extension Service

HomeBase is a National Association of Home Builders (NAHB) Research Center program that is designed to broaden communication channels and create a greater flow of information and interchange among all participants in the home building industry. The program responds to numerous communication and informational problems that arise from the industry uniquely decentralized.

The program provides a one-stop information resource for home builders on technological advances in management and materials, and serves as a communication vehicle between builders and product manufacturers. HomeBase will also develop a national network of technology extension offices that will provide information on all technical aspects of home building. Participants in the program included builders, remodelers, product suppliers, state and local home builder associations, the National Institute of Standards and Technology, and its network of Manufacturing Extension Centers.

The HomeBase program will identify home building needs, identify resource requirements, and coordinate linkages for the interchange of information. Links in the communications network include manufacturing extension centers, the NAHB Research Center, manufacturers, trade associations, universities, and state government agencies.

Special attention and resources will be focused on the needs of building firms, the majority of which are small, with insufficient access to information. Builder services include 800 number for consulting by phone, on-site technical support, delivery of materials by fax or by mail, and seminars and workshops. Additional communication tools being developed included an on-line database on technologies and products, and a CD-ROM Building Products Catalog. The program includes aggressive information outreach to builders, including information dissemination to 850 state and local home builder associations, trade publications,

building supply distributors, building code departments, and radio spots.

Benefits include increased information delivery to builders, collection of information from builders on what does and doesn't work, and rapid dissemination to builders of early warning information on field problems with products and systems.

Obstacles include the familiar ones of scarce resources, large numbers of tasks to achieve, and insufficient funding to effectively reach the large number of small firms that make up the residential building industry.

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## 3.5 IBACOS/DOE/NREL: Bringing Innovation to the Home Building Industry

### IBACOS

A unique industry collaboration of leading manufacturers, builders, and the DOE, dedicated to bringing innovation to the home building industry.

**Why Needed?**

The home building industry is a very fragmented one with complex distribution channels, hundreds of thousands of small players, and little true R&D investment. There is no one entity who takes a holistic look at the home and integrates the elements into a better whole.

**A Program Description**

IBACOS (Integrated Building and Construction Solutions) is in the third year of a 4-year development program with DOE/National Renewable Energy Lab (NREL) to help bring a systems approach to building homes. The program's reference and laboratory houses demonstrate integrated new technologies designed, manufactured, and installed as a system. Technologies include combined wall construction, heating, ventilating and air quality systems, plumbing, and energy efficient shell and panel concepts.

**IBACOS Vision**

To help builders build better homes for America's future. This approach is called EQA™- homes that are energy **Efficient** and **Environmentally** responsive, **Quick** to build and top **Quality**, **Affordable** and **Adaptable**.

**IBACOS Mission**

To work with leading manufacturers to develop new, integrated building products and systems. To bring best practices and improved productivity approaches to builders.

**Why a DOE Alliance?**

Energy efficiency is a key part of the IBACOS vision and an area that most builders and manufacturers do not truly understand or value. Energy efficiency is difficult to achieve cost- effectively and requires an overall systems understanding to building, unlike industry with its short term perspective, and has already undertaken much energy efficiency research and technology development. It seemed natural to combine this with industry's short-term approach and help catalyze manufacturers

and builders to be more proactive and visionary. Ultimately, technology transfer to practice, resulting in better, more efficient homes for consumers and overall society is the key goal.

**DOE was creating an easier way of working with industry in more of a win-win flexible relationship.**

**Collaboration Obstacle and Statue**

*Manufacturer Perception.* Michael Dickens decided to approach DOE to join forces with IBACOS in 1991; the initial reaction from our member companies was one of surprise. They questioned the value of working with the government, due to their own historical view of public-private projects. Michael Dickens assured them that times had changed and DOE was creating an easier way of working with industry in more of a win-win, flexible relationship. Our member companies have since become impressed with DOE's attitude and approach and see the value in the partnership.

*Intellectual Property.* It has not really been a problem but rather an initial perception of a problem from our manufacturers' perspective. IBACOS and/or our manufacturers create and own the ideas, solutions or patents. DOE is interested less in their ownership and more in transfer to practice, with resultant benefits of energy and efficiency.

*Entrenched Bureaucracy.* Over the last three years, the amount of reporting of our programs' progress to DOE has lessened to more of an industry-level of communications. This had allowed us to spend more valuable time and resources on the work and not on reporting.

*Slow Contracts/Decision.* Our DOE contact has been handled via DOE's NREL. This was a very good step and streamlined contractual and decision-making process. Over the last three years this has improved even further as NREL again became more industry-like via 'work-outs.'

*Inflexible Deliverables.* Working with builders often results in changed agendas, projects, scope, deadlines, etc. In the early years this caused havoc with our agreed deliverable to DOE/NREL. We have since been allowed to be more flexible on the details and scope of the program deliverables.

*Different Agendas.* At times, this is a challenge: manufacturers want short-term sales opportunities; builders want cost reduction; DOE wants increased energy efficiency. Often these are at odds with each other. DOE now understands that their own agenda will only be served by first serving the needs of builders and manufacturers. A common vision and common sense objectives are critical to success.

*Builder Perception.* On initial contact builders would expect free service due to IBACOS's funding relationship with DOE and manufacturers. This was an issue since non-payments often result in non-respect of value. We created win-win joint development programs with builders whereby they fund one-third to one-half of their individual programs.

**Conclusion.**

The collaboration with DOE is an excellent, needed, working, win-win partnership.

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### 3.6 Engineering Controls for Asphalt Paving Equipment: A Partnership between the Asphalt Paving Industry and the Federal Government

The asphalt paving engineering controls project is a good example of the success which can be achieved when the federal government and industry join together for a common goal. Key players in the success story are the National Asphalt Pavement Association (NAPA), the FHWA, NIOSH, five asphalt paver manufacturers, organized labor, and several state Departments of Transportation (DOTs).

The engineering controls project for asphalt paving equipment originated in 1993 and was the brain child of NAPA and its members. Because the science concerning worker health effects is inconclusive, NAPA and its members took it upon themselves to investigate ways to improve the overall working environment for asphalt paving workings and reduce their exposure to material volatilized from the asphalt paving during paving operations. NAPA and its members viewed this project as a win-win scenario for both the workers and the employers. From these efforts, three contractor/paver manufacturer teams were formed to develop and evaluate different control designs for paving equipment.

**The asphalt paving engineering controls project is a good example of the success which can be achieved when the federal government and industry join together for a common goal.**

These efforts lead to the founding of the NAPA Engineering Controls Task Force in May of 1993. The goal of the Task Force was to take a proactive approach to improve the overall working environment and conditions during hot mix asphalt paving operations. Initial field trials of prototype equipment indicated that local exhaust ventilation techniques held promise. However, the Task Force recognized the need for outside assistance in conducting a thorough performance evaluation to optimize the engineering controls potential. Recognizing this need, NAPA approached FHWA with a proposal requesting NIOSH to assist each participating manufacturer with the optimization of their prototype engineering control design. FHWA, recognizing the important role that asphalt pavements serve in the nation's infrastructure and transportation system, saw merits in the project, and funding was provided under the Applied Research and Technology Program of the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA). Under the program, NIOSH would evaluate the potential of the manufacturers' engineering control design and make recommendations on how the efficiency of the controls could be optimized. After the manufacturers made modifications, NIOSH would then evaluate the engineering controls efficiency under actual field paving operations. Once funding for the project

was received, all the major pavement manufacturers, which represent over 80% of the highway-class pavers sold, decided to participate in the project.

NIOSH engineers, in conjunction with NAPA's Engineering Controls Task Force, developed a two-phase evaluation process to assist in the deployment of the engineering controls systems and optimization of the manufacturers' designs. Phase I of the project consisted of stationary tests with surrogate contaminants to evaluate the control system's efficiency to capture the contaminants. These evaluations were carried out at each participating manufacturer's facility. During Phase I, theatrical smoke provided qualitative performance evaluation, while tracer gas techniques were employed to quantify the control system's exhaust volume and capture efficiency.

The shop or laboratory evaluations of the engineering controls proved extremely useful in refining and optimizing the designs. Several manufacturers discovered they had insufficient exhaust capacity to capture and remove the contaminants. One manufacturer used the shop evaluation to select the best performing hood among three prospective designs. Another manufacturer discovered that the engine cooling air was blowing into the collection hood and disrupting the control's capture velocity. From the shop evaluations, all manufacturers identified areas where their initial designs were susceptible to cross-draft interferences. Based on the shop evaluation data, the manufacturers were able to refine their designs in preparation for Phase II, which will be conducted this spring and summer during actual paving operations.

For additional information please contact:
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### 3.7 Innovative Seismic Solution for VA Medical Center at Long Beach, California

The first medical facility in the United States to use seismic base isolation retrofit while still remaining fully in operations is now almost complete at the Department of Veterans Affairs Medical Center (VAMC) in Long Beach, California. This landmark project for the U.S. and the world represents a new direction by VA in its long history of seismic upgrading its existing facilities.

This 28-year old, 12 story, 31,950 square meter hospital is located on a particularly precarious site. After detailed investigation and analysis, the decision was made to correct the seismic deficiencies in the existing building and protect the medical center by using "base isolation" in the hospital's renovation. The project included inserting large, lead-core rubber pads into the concrete columns and walls in the basement of the hospital. Sections of the walls and columns above the foundations and below the first floor were cut away so isolators and sliders could be installed. By "isolating" the hospital footprint of 4,860 square meters from the ground, the amount of force and displacement transmitted into the structure by an earthquake is significantly reduced.

As of January 1996, all the 128 base isolators and 36 sliders were installed. The entire installation process took approximately one year. Sawcutting the concrete walls at the plane of isolation, the final step towards the transition of the hospital building from the "fixed" base structure to an "isolated" structure, was completed by mid-February 1996. The modification of adjacent connected buildings (the outpatient clinic and bridge) is also complete. There is now a .9M wide, 315 meters long "moat" around the entire perimeter of the hospital building, so it is free to move during a seismic event without any interference from adjacent structures. Also, all mechanical, electrical, and plumbing services crossing the plane of isolation were modified to allow movement of the isolated structure and enable the hospital to remain fully functioning after an earthquake.

The design team, VA's Office of Facilities Management (FM) and its consulting A/E, Albert C. Martin and Associates, with Nabih Youssef & Associates Structural Engineers, engineered a comprehensive earthquake monitoring instrumentation package in collaboration with the United States Geological Survey (USGS), so the response of the building in future earthquakes might be evaluated. Despite the complexity of the intricate design and construction project, successful partnering among the design team with: the designer of the isolators, Dynamic Isolation Systems; the staff of the VAMC; the contractor, Dillingham Construction; and their base isolation subcontractor, Sheedy Drayage, the project will be completed on time, within budget, and with minimum impact to the existing operations of the long Beach Medical Center.

**Project Benefits:**

- The hospital will withstand forces generated by seismic activity up to a maximum credible earthquake of 7.1 magnitude on the Newfront Englewood fault and 8.3 on more distant San Andreas fault. The hospital is designed to remain fully in operation should seismic activity reach these limits;
- Seismic Base Isolation had a substantial economic advantage, a $6 million savings compared with other alternatives, considering the business disruption costs and the value of building contents;
- Construction time was reduced from other alternatives considered;
- There was no loss of functional space. In traditional shear wall strengthening, walls would have run through functional spaces and considerable reconfiguration would have been required;
- The entire hospital has remained completely in operation throughout the entire retrofit process, without occupants being disturbed throughout the building by the noise, vibration, debris and dust, as well as phasing of renovation work in different areas, all of which would have been maximized by other methodologies for seismic upgrading; and
- There was no interruption of services to patients, human disruption or dislocation to patients or staff, and no business-loss.

**Conclusion.**

In sum, Base Isolation provided this high

level of safety for the hospital, its occupants, and maintained building functionality, economically, and without interruption.

| | |
|---|---|
| Construction Cost: | $20.4 million |
| Construction Start: | 3/21/94 |
| Scheduled Completion: | 6/1/96 |

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Additional success stories may be found in Appendix D.

## 4. Intellectual Property Rights

The material in this section comes from the Workshop presentation by Terry Lynch, Licensing/CRADA Officer at the National Institute of Standards and Technology. Workshop participants were given the opportunity to ask specific questions on these issues.

A key challenge in developing partnerships is the issue of intellectual property rights. Intellectual property issues can arise from both sides of a public/private partnership. The government often has significant intellectual property that it would like to transfer to the private sector. At the same time, the private sector may bring intellectual property to the table that it wants to protect. In both cases, the private sector interest in intellectual property -- either acquiring or protecting it -- needs to be a consideration in any partnership agreement, as well as the laws and regulations by which the government must operate.

With this in mind, companies and government agencies interested in developing a partnership arrangement should understand the following points:

- the stages of technology that can be expected from the Federal laboratory
- the means of establishing a working relationship with a Federal laboratory
- the expectations of what a Federal laboratory can do for the private sector
- the limitations on what the Federal sector can do.

These points are discussed below, as they affect intellectual property issues.

**Stages of Technology** -- The laboratories work with technologies in three major stages of development:

- Concept -- the first phase of developing and testing the idea for a technology to solve a specific problem
- Prototype -- the construction of an initial working technology for testing and working out design issues, often at the lab or bench scale
- Beta -- the next evolutionary stage of the technology after the initial bugs are worked out. This stage often includes field-scale testing and demonstration.

Partnerships could be established and intellectual property be an issue at any stage of the technology development.

**Establishing a Working Relationship** -- The establishment of a working relationship can be approached through a variety of vehicles designed to create synergism. These relationships can occur at any stage of the process and opportunities exist for licensing at either the concept, prototype, or beta stages; however, in this, as in any aspect of collaboration, timing is important. The appropriate time to become involved in a partnership will vary depending on the technology in question. The relationship usually focuses on working on industry-wide issues through consortia. Often these consortia are formed through the mechanism of a CRADA.

**Realistic Expectations** -- Government laboratories have a wide variety of means to work with private sector companies, including facilities use agreements, guest researcher agreements, and support through

specifically legislated programs and initiatives (e.g., Small Business Innovative Research (SBIR), Advanced Technology Program (ATP), Technology Reinvestment Project (TRP), SEMATECH, Manufacturing Extension Partnership (MEP), and the Malcolm Baldridge Quality Award). While partners can make real progress through agreements of these types, none of these means are without limitations. Realistic expectations should, therefore, focus on incremental improvements in working relationships and technology development. Participants should be prepared to commit resources over an extended period of time for eventual results, rather than expecting immediate breakthroughs and dramatic leaps of technology that will create new growth or rescue a struggling enterprise.

**For companies to license technology from a Federal lab, it must be patentable. The government cannot copyright information, nor license "know-how."**

**Limitations** -- The expectations of what can be obtained from a Federal lab are just as important to keep in mind as are the advantages. For example, private sector partners should **not** expect to obtain the following:

- Funding of their portion of the CRADA
- "Contract" research
- Unlimited confidentiality of mutually achieved research results
- Granting and/or retention of an exclusive license without sufficient commercialization
- "Royalty free" licenses
- Retention of government use on research results and/or licensed technology
- U.S. government manufacture
- Warranties.

**CRADAs** -- Since CRADAs are an important means of partnership when protection of intellectual property is important, it is useful to consider more details about what they are and how they may be applied.

- CRADAs are used for joint research projects of mutual interest when intellectual property, research results and/or confidentiality are important.
- Private sector partners may contribute research staff, equipment, facilities, and funds.
- Government partners may contribute research staff, equipment, facilities, and funds (to other Federal partners only).
- CRADAs can protect confidential information to the extent permitted by law.
- CRADAs can protect research results from FOIA requests for up to 5 years.
- CRADAS can provide for exclusive licensing rights to resulting inventions.

For companies to license technology from a Federal laboratory, it must be patentable. The government cannot copyright information, nor license "know-how." Common conditions of patenting technology that will need to be worked out include: royalties, reimbursement of direct filing costs, field of use of the technology, U.S. manufacture for the U.S. market, and march-in rights.

Under CRADAs, partners receive the right to negotiate exclusive or nonexclusive (their choice) license to CRADA-derived inventions (either joint or sole). Under an Industrial Fellow Agreement, all intellectual property rights go to the host company.

# 5. Mechanisms for Collaboration

This section presents the results of the first Workshop breakout session on mechanisms for collaboration. The section is organized by the different collaboration mechanism topics addressed by the breakout groups. For each topic, a description that was provided to participants is given below, along with the group's analysis of the issues and recommendations the group developed. Participants were asked to brainstorm and discuss the mechanism's strengths and weaknesses, potential ways of improving the mechanism, and new ideas for related collaborative mechanisms. The mechanisms discussed are:

- Use of government facilities and capabilities and role of government as consultant/assistance provider
- Commercialization of government lab technologies
- Joint research agreements
- Jointly-sponsored research centers
- Research consortia and large-scale industry-wide network programs.

## 5.1 Use of Government Facilities and Capabilities and Role of Government as Consultant/Assistance Provider

*Topic description:*

Government laboratories have equipment, facilities, and expertise not always available in industry, universities, or commercial testing laboratories. Many government laboratories make such equipment and testing facilities available for use by private sector organizations, usually with professional and/or laboratory technician help. Information on research at government laboratories is made available through publications and talks; however, research experts are also available to discuss further details of any government-funded research in response to inquiries. Consulting advice by government experts who have specialized knowledge can be made available either free or for a fee depending on the scope of the effort.

*Analysis:*

There are several general issues that underlie industry's consideration of this collaboration mechanism. The first is the fact that there are general cultural differences between government agencies and laboratories and industrial organizations. In order for collaboration to be successful between the two, there needs to be a mutual respect and understanding, as well as willingness to compromise in order to develop arrangements that are acceptable to both parties. Historically, government has been labeled as being unable to understand and respond to industrial concerns driven by market demands and fast product cycles. On the other hand, industry often lacks appreciation of the Federal role and its vast technical expertise. Industry's willingness to use government facilities and other resources, such as staff for consulting, depends on the individual organization's comfort level with the responsiveness and understanding of the government to its needs and operating principles/drivers. Industry may be intimidated by the size and scope of the opportunity or challenge of working with the government. In addition, the perceived disconnect between the two sectors and both

sectors' lack of awareness of commercialization potential can also be limiting. Since it can be difficult for both sectors to keep abreast of the other's commercialization opportunities, successful partnering is sometimes challenging.

The uncertainty of the political environment in which government facilities and resources are entrenched is also a factor in determining industry's willingness and comfort level with taking on the government as a collaborator or partner. The effects of limited and uncertain long-term program funding and politicians' "whims" are uncertain. These uncertainties often result in general uneasiness on the part of industry to get involved with the government. Some type of "guarantee" of project continuation and funding would be useful to encourage industry involvement with the government.

In general, industry seems to lack awareness of what kinds of government resources are available to them and the extent to which they are available. Prior to the Workshop, many participants knew very little about the types of resources government has to offer. This lack of awareness is an important factor to consider when looking at the frequency to date of public/private sector collaboration using this mechanism. Increased education could be beneficial in encouraging additional collaboration. One issue not resolved during the breakout group's discussion was what types of differences in availability and other issues exist between government-owned, government-operated facilities and government-owned, contractor-operated facilities.

The use of government facilities offers several strengths to industry, but participants felt that there are some weaknesses as well. Major strengths include the unique capabilities which these facilities offer and their general availability for use without excessive restrictions. An added benefit is the fact that these are existing facilities in which many sunk costs and overheads have already been paid. However, the participants in this group felt that the cost of using government facilities can be prohibitive. Additionally, the facilities are often not easily accessible geographically to a potential partner, and cross-agency coordination can be difficult if there is a need for multiple agency involvement. Another potential shortcoming of this mechanism is that uncertainty in long-term facility funding and support can make planning difficult for partners.

**Some type of "guarantee" of project continuation and funding would be useful to encourage industry involvement with the government.**

The use of government staff as consultants offers several benefits to industry. This mechanism allows partners access to decentralized expertise not available elsewhere, including the institutional memory that comes with the extensive R&D that has taken place in the government. A major strength is that by industry partners working with government staff as consultants, the government staff can be aware of and focused on end-user applications, or in other words, the needs of the marketplace. Increased government awareness of marketplace needs will benefit both industry and the government as their efforts become more in-tune with each other. However, industry is concerned about the potentially

high cost, the limited government liability, the limited amount of time available for a consultant to work with a partner, and the fact that these resources are not centralized. Again, lack of knowledge about availability of government staff as consultants is also a limitation of the utilization of this mechanism.

*Recommendations:*

The discussion group developed several recommendations on improving the use of government facilities and capabilities and the role of the government as a consultant or assistance provider in collaboration with the private sector. First of all, the government should provide a better catalogue of resources focused on building and construction. In addition to the traditional printed format, this catalogue could be announced and coordinated via the World Wide Web. Links to appropriate Web sites describing facilities and resources would also be useful. Since increased industry awareness of governmental resources was a key topic of the Workshop, participants acknowledged the government's efforts in working on publicizing their facilities. However, continued industry education on available government resources is needed.

Other recommendations fall under the category of encouraging a stronger link between industry needs and government capabilities. Suggestions included making explicit efforts to link the two by expanding programs that enable government research influenced by industry and by the government adopting a general "customer orientation" mentality. This would encourage market-driven research and development by government, which in turn would encourage collaboration between the government and the private sector.

Specific measures taken to facilitate industry access to use of government facilities would be very useful. The group felt that private sector's access to labs needed to be improved. The group also would like to see standardized CRADA procedures, as well as the uniform administration of CRADAs. The government should also advocate the use of sector-wide agreements to allow for this.

General recommendations on the government's role in technology innovation were also provided. The government and the private sector should continue to identify and reduce barriers to commercial innovation. Both sectors should, for their respective sector, continue to demonstrate the benefits of technology advancement to system owners, make the transition to technology-pull, establish models of success, create a constituency for innovation, and publicize capabilities (resources/benefits) to potential clients. For the government, this would require creating a management thrust towards commercialization. Other recommendations specifically targeted to the government include enabling the government to promote innovation through the procurement of advanced technology and using Federal facilities for demonstration purposes in order to reduce liability on the private sector. As government/industry collaborations increase, however, it is important that the impartiality of the government is preserved. Participants suggested that an analysis of industry's use of government expertise could indicate other areas for improvement.

## 5.2 Commercialization of Government Lab Technologies

*Topic description:*

Research at government laboratories sometimes results in technologies that offer the prospect of development into successful commercial products. As it is not the government's role to produce commercial products, these technologies are often made available to industry and universities for commercial development or other purposes under various licensing arrangements. In some instances, when products are developed by the private sector specifically for the government with government funds, e.g., defense equipment, the development of related commercial products provides additional opportunities for the private sector.

*Analysis:*

Strengths of this collaboration mechanism include the vast number and types of technologies that are developed under Federal facilities and in Federal laboratoriess that are available for commercial development or licensing. However, participants felt that a major weakness of this method of collaboration is that there is no comprehensive inventory of government technologies available for commercialization. While some inventories do exist, these are fragmented (often by agency) and not widely known. Additionally, there is no mechanism for interagency technology transfer, so many agencies are not aware of what others are developing that may be useful to them. A key problem is the lack of a government-wide program for uniform cooperative technology development and transfer. The CRADA has worked well, but its efficacy and usefulness is hindered by a lack of resources and responsibility to span from prototype to production model.

**Additionally, there is no mechanism for interagency technology transfer.**

*Recommendations:*

The strongest recommendation for improving this mechanism is the development *and funding* of a government-wide uniform program (similar to the U.S. Army Corps of Engineers' CPAR program or the DOD's TRP for cooperative technology transfer. Programs such as these have benefited the industry, the government, and the nation as a whole. Critical to any success, however, is sustained and sufficient funding. Also critical for successful commercialization of government lab technologies is early industrial involvement in order to identify true commercial opportunities; the partners can help shape the products. Another recommendation of this group is that industry itself must market (to Congress) the need for funding R&D programs and technology transfer programs such as CPAR. The group urged participants and the industry as a whole to write Congress about these issues. Another way of improving this mechanism is by the government ensuring resources for demonstration and validation of technologies and by shielding new technology from liability suits during demonstration projects.

## 5.3 Joint Research Agreements

*Topic description:*

When government research parallels research of interest to the private sector, universities, and/or non-profit institutions, a joint research effort is often beneficial to all parties. Each party involved contributes to the work either with specific expertise, personnel, equipment, funds, or facilities. With these combined resources, projects are often completed more quickly or more thoroughly than if the work was done by only one party. These efforts also allow the parties involved to pursue work that could not be undertaken individually because of cost or other constraints. An agreement is needed between all parties that identifies each party's responsibilities to the project and identifies the owners of any intellectual property that is provided or developed during the course of the project.

**Participants also stated that sometimes the government feels that there is a hidden agenda among industry partners.**

*Analysis:*

There are several strengths of collaborating via joint research agreements, including, perhaps most importantly, the ability to leverage available funds, personnel, equipment and other assets, and knowledge. In addition, joint research agreements with the government offer the strength of a very large potential customer base (the government itself). Joint research agreements allow for rapid market development, rapid implementation opportunity, as well as healthy and productive interactions among government, industry, universities, and associations. They also provide a partner with external access to special facilities and expertise that may otherwise be difficult to find.

One disadvantage or weakness of joint research agreements is one that is inherent in any R&D-intensive industrial activity: there is no guarantee that the original partners will benefit from the commercial product. This weakness, combined with others, such as the often lengthy time required to develop common standards and working operating procedures, illustrates the types of potential risks of joint research agreements. Participants felt that current joint research agreements (with the government) often lack flexibility, especially in areas of intellectual property rights, non-exclusive licensing, and product liabilities/indemnification. Working with the government also brings up concerns such as the possibility of an erratic timing schedule and uncertain and erratic funding. These issues may force a short-term focus, which may ultimately limit the collaboration effort. Participants also stated that sometimes the government feels that there is a hidden agenda among industry partners. General concern was expressed about the lack of accurate, unbiased evaluation and feedback mechanisms to measure success of joint research agreements or collaborative programs, which increases the danger of eliminating "good" programs with the "bad" ones during budget cuts.

*Recommendations:*

Recommendations on improving this mechanism include expanding joint research opportunities and programs such as CRADAs, the CPAR program, and consortia. These new arrangements should maintain the current strengths while increasing flexibility. A "CRADA

Handbook" should be developed that provides a spectrum of acceptable options to address issues such as intellectual property and licensing for ease in developing the actual legal agreement between parties. Options should also include full funding up-front and multi-year funding. These new programs should create opportunities for open competition so as to stimulate technology innovation. Looking further into the future, participants suggested that improved or new mechanisms should consider the continued necessity to leverage manpower and assets, the need to look at product characteristics and life-cycle costs, the need for more education and communication to take advantage of past experiences, and built-in checks and balances that allow for better product testing and approvals.

### 5.4 Jointly-Sponsored Research Centers

*Topic description:*

Centers of excellence in specific areas of research can be sponsored jointly by government, industry, universities, and/or non-profit institutions. Sponsorship can include the provision of funds, facilities, or other resources. Funds can be obtained from sources such as government contracts or grants, industry, endowments, or private foundations. These centers can be used for various purposes, e.g., testing sites, clearinghouse functions, laboratory research, etc.

*Analysis:*

Strengths of this type of collaboration include the ability to leverage resources, the ability to provide flexibility and multi-disciplinary teaming, and the ability to stimulate and assist innovation and technology transfer. Jointly-sponsored research centers often lead to a great diversity in the center's talent base and perspective, which offers partners greater thinking power and enhanced awareness. Centers also offer the potential for continuity of experience base and enhanced credibility/validation. Weaknesses include those of any type of collaborative effort, including human factors, such as differences in views, cultural background, organizational procedures, etc. There is potential for conflicts about differences in center management direction and style between the center staff and the sponsor. The strength that comes from diversity can also be a potential weaknesses in that that diversity may lead to a difference in priorities. With many organizations working together, there may be a lack of a clear sense of direction or a uniform goal. Some participants felt that these types of centers can be seen as too exclusive. The need for sustained resources can also be a difficulty. In order for these types of arrangements to be successful, partners need to have mutual trust and respect, a common vision or problem definition, and similar perceptions about the opportunities available. An internal and external "champion" increases the possibility for success. Additionally, win-win agreements must be developed, and all partners must share in the rewards. Established timelines and milestones are necessary to keep the collaborative effort on

**The strength that comes from diversity can also be a potential weakness in that that diversity may lead to a difference in priorities.**

track.

*Recommendations:*

Suggestions for improving this mechanism include allowing personnel exchange, changing the tax laws to encourage this type of collaboration, and developing other methods to increase the real value to all stakeholders. Jointly-sponsored research centers need a long-term/core commitment from the government or other sponsor. These types of collaborative efforts would benefit from more distinct tie-ins to industry needs and desires. In general, an increased investment in R&D and an increased focus on human factors R&D could help to improve these types of collaborative arrangements. Specific suggestions for new collaborations included pursuing international opportunities, increased state and local organization participation, and the input of construction industry labor. These centers could also work together to diffuse or deploy technology to small and medium firms. It is very important for champions of these types of arrangements to tell their stories of success and explain the reasons for collaboration. Leadership is needed by trade/technical, and professional organizations to help develop these type of arrangements. Existing centers need to utilize information technologies to increase their outreach.

### 5.5 Research Consortia and Large-Scale Industry-wide Network Programs

*Topic description:*

Some research topics are of a generic nature, with the results of interest to a wide group of manufacturers or organizations. The members of a consortium contribute funds, facilities, equipment, or materials to those performing the research. In return, the consortium members have first-hand knowledge of the progress of the research, and perhaps share in the rights to any intellectual property resulting from this work. Information on the research reaches consortium members sometimes years before it is published. Consortia may also serve the purpose of communication and coordination among various organizations involved in a particular topic or field. Large-scale, industry-wide network programs are often high-visibility, resource-intensive efforts involving participation from government, private sector organizations, and universities. These programs may have several different components which address various parts of a particular topic or problem.

*Analysis:*

Strengths and benefits of research consortia are similar to those mentioned for the other mechanisms. They include the leveraging of money and resources, the synergy promoted among members, and the integration and harmony developed by partnership among federal and state government, universities, and industry. Consortia members often have complementary expertise and roles. A strength is that consortia are usually created with a vested interest in commercialization and often have a clear market definition. Strong leadership/management and opportunities for industry-wide education and communication are other potential strengths of this mechanism. Conversely, these types of collaborations also have lack of clear market definition, lack of leadership

or strong management, and lack of communication and education as potential weaknesses. Other weaknesses include administrative costs and delayed project time or late deliverables.

There are several prerequisites for success of research consortia and large-scale industry-wide networks. The first, according to Workshop participants, is that an industry need (for the collaborative effort) must exist. A compelling mission and goal, strong leadership, good management with a clear plan, and strong cooperation are also essential for success. A clear understanding of the market (e.g., a business plan), understanding of legal requirements and obligations, early payback to partners, realistic expectations as to costs and benefits, and a clear understanding of all partners' roles will improve chances of success. Critical to this, however, are mutually agreed upon definitions for measuring success (or acknowledged definitions unique to each partner). Continual benchmarking/monitoring should also be required. In order to be most beneficial to the industry, these consortia must have support from related associations and practitioners. A strong commitment from both the industry and the government is also needed. The government should act as a facilitator in these types of arrangements. The specifics of these arrangements are unique to the technology and goal, and these will determine the number and types of participants (partners) desired. There is no single clear model on which to base the organization of research consortia or large-scale industry-wide networks.

*Recommendations:*

Participants felt that the government should be more flexible in serving the public and in collaborating with industry through these mechanisms. The group felt that both industry and government need more skills in setting up consortia. Dedicated resources and training, along with continued cross-sector workshops would be beneficial. Analyses of failures of consortia and similar collaborations would also be useful in determining how to improve them. In terms of defining new related mechanisms, the group suggested looking at the successes and failures of these type of collaborations in other countries, such as in Japan and in the European countries, to get new ideas. Consortia with a decentralized distribution mode and "virtual" mechanisms were also suggested. Participants felt that consortia should become more cost- and market-driven. This group also suggested creating a specific consortium focused on systems demand, operation and maintenance.

**Participants felt that consortia should become more cost- and market-driven.**

# 6. Opportunities for Partnerships

This section presents the results of the second Workshop breakout session on opportunities for partnership. These sessions focused on improving the public sector's role in collaboration with the construction industry to fill existing voids. Participants were asked to brainstorm and discuss gaps or areas of weakness in the industry and opportunities for improving government roles or creating public/private sector working relationships to address the identified gaps. A description of the topic provided to participants, the group's analysis of the issues, and recommendations the group developed are given below. The specific topics discussed are:

- Research and pre-commercial technology development
- Technology demonstration and deployment
- Information dissemination
- Cross-industry communication.

## 6.1 Research and Pre-commercial Technology Development

*Topic description:*

It is not the job of government to develop commercial products. However, basic and applied research that precede commercial development are often part of agency missions. This pre-commercial research can include the development of performance measures and test protocols. Partnerships between the private sector, universities, and the government in this type of research and technology development provides information that can be extremely valuable to all parties. Results of these partnerships may then be used, modified, and/or expanded for individual purposes, including product development.

*Analysis:*

Several gaps or weaknesses in the area of research and pre-commercial technology development were identified, with respect to both government's role and industry's role. First, there appears to be a lack of clear communication and interaction among Federal government agencies. It is thus difficult for different agencies to utilize other agencies' expertise and experience where appropriate. This lack of communication and interaction also leaves the government prone to duplicative research efforts. Industry's lack of knowledge about agency missions, and the perception that some of these missions overlap, makes it difficult and confusing for industry to inquire about or to determine the government's overall involvement in research and pre-commercial technology development in the construction field. This, in turn, limits the establishment of collaborative efforts. As mentioned previously, participants felt that industry does not know the capabilities of the government that may be able to help them; there is no centralized "network" to tap. There also appears to be a lack of coordination with state and local agencies.

Participants felt that the lack of Federal funding for construction-related research and pre-commercial technology development was also a gap that exists today. The lack of CPAR-like programs (the program had no funding for FY96), which clearly benefit both industry and the government, was considered a major void in this area. They felt that

government research and technology thrusts should be and must be linked to a demonstrated market need. The perception, whether true or not, is that government activities are too far removed from marketplace or industrial needs and applications to be clearly useful. (The CPAR program seems to benefit both the needs of the government and the nation.) Similarly, the government's working schedule seems inconsistent with private sector needs. The government is viewed as being "slow" (in terms of project time, paperwork follow through, etc.) when working with the private sector.

A major weakness with respect to industry's role in research and pre-commercial technology development is the fact that there is a lack of motivation in the construction industry to conduct R&D. There have been many reasons cited for this, including the fragmentation and diversity of the industry, the regulatory and liability issues associated with new products, adversarial relations within the industry, lack of clear industry leadership, parochialism, and financial disincentives. Industry often does not see the benefits of conducting such research and development because it often does not recognize its own needs for R&D. Industry must define its needs through a central goal setting process, and the government should provide funding and other support to help industry achieve these needs and goals. (Note: this was the focus of the National Construction Goals process.) Industry also often feels that it must have core funding from government or an industry group in order to pursue R&D, because of the financial disincentives to pursue R&D alone. Research and pre-commercial technology development must be cost-effective. Cost-effectiveness is often difficult to prove, however, to budget-minded, bottom-line driven CEOs, as results and benefits may not accrue to the company for months or even years. Demonstrations of new innovative technologies or products are also difficult because a one-time demonstration is often not enough to generate interest in a product. Funding for additional demonstrations is difficult to find, though. Participants felt that because there is a general lack of funding from all sources, industry must be willing to share costs, with government or other partners, to conduct R&D. Collaborations are thus necessary in the industry.

**Demonstrations of new innovative technologies or products are also difficult because a one-time demonstration is often not enough to generate interest in a product.**

Other issues such as parochialism make fear of legal liability and of losing confidentiality critical issues as well in collaborative research and pre-commercial technology development. Industry partners must make legal agreements with their industrial competitors on cooperative research. The involvement of lawyers and the necessary "paperwork" are seen as additional money- and time-drainers and obstacles to accomplishment of goals.

*Recommendations:*

The group recommended several ways to improve the government's role in research and pre-commercial technology development. These recommendations

involve necessary actions by industry to help improve the public sector's role. Industry should provide data on its national needs to agencies. Agencies should align their missions accordingly and thus identify and focus on specific research areas to meet these needs, especially those that have a national interest and a strong potential market value. A formal mechanism should be established to allow the government and industry to prioritize these research needs. Participants recommended that the C&B Subcommittee and CERF help to set these goals/needs and work with the various industry sectors and government (Congress) to build support for this concept. Participants also recommended educating the public and Congress on the needs of (and reasons for) construction research, and developing a short list of key/enabling technologies critical to meet these needs. (Note: this was a focus of the National Construction Goals process and is presented in the C&B publication previously mentioned.)

**One recommendation was the creation of a National Construction Research Council comprised of government, industry, and academic representatives.**

There is no single source for information on government R&D in construction, and thus industry does not know where to go to look for a particular potential collaboration opportunity. The government should increase its efforts to showcase successful collaborations with industry and should develop a "roadmap" of the Federal facilities and laboratories. This roadmap could suggest and would facilitate "matchmaking" with industry, universities, and associations. The roadmap should contain detailed information on facility and laboratory capabilities and points of contact.

Participants suggested that the C&B Subcommittee and CERF take the lead in building support for increased government funding for construction-related research. A specific recommendation was a government "set aside" for research, development, and demonstration purposes in Federal construction. Other suggestions for improving the government sector's role in research and pre-commercial technology development were increasing the scope of the Federal sector as a technology demonstration "testbed" and using the government procurement process as a driver for innovative technology. The breakout group thought that the CPAR program was a good model on which to develop new collaborative programs, and that these programs should be expanded or established at all agencies.

One recommended public/private sector working relationship to fill the voids identified was the creation of a National Construction Research Council comprised of government, industry, and academic representatives. This Council would bring diverse views to the table and would establish construction research needs and priorities. The Council should monitor and evaluate its progress and effectiveness, and should disseminate information widely. The Council could work to obtain private or individual input in setting the research agenda and priorities by using industry directories to pinpoint selected individuals. Surveying these individuals would help to

obtain more input into the process and would assist the industry in developing consensus on important issues. A similar consortia focused on policy issues should also be developed. The group referenced a Federal Facilities Council report (#129) titled, "Federal Policies to Foster Innovation and Improvement in Construction Facilities", published by the National Academy Press in 1996.

The public and private sectors should work together to provide incentives for collaboration among government, industry, academia, and should work to simplify intellectual property and indemnification issues in public/private contracts. These are contentious issues within industry. Industry should continue to be educated about these issues by the government as well as partners involved in current collaborative efforts. Participants specifically mentioned the CONMAT (High-Performance CONstruction MATerials and Systems) Council as a good model for research and pre-commercial technology development collaboration. CONMAT should be used as a collaboration success story and those involved should continue to improve its effectiveness. The CONMAT model should be extended to other areas of construction, such as construction automation, condition assessment, prefabrication, and infrastructure robustness to hazards.

### 6.2 Technology Demonstration and Deployment

*Topic description:*

Some government agencies are the builders and operators of facilities. As such, it is in their interest to take advantage of innovations in both design and construction. Government facilities can provide a vehicle for demonstrating innovative materials, products, and construction technologies. Government agencies and laboratories can also work with partners on deployment of technologies.

**The CONMAT model should be extended to other areas of construction...**

*Analysis:*

Although many demonstrations are being conducted, the current situation in construction technology demonstration and deployment is one that is more ad-hoc than organized. Current demonstrations tend to be focused on proving technical capabilities one time only (at the demonstration) rather than to be organized and conducted to be most convincing to potential users. One demonstration is not enough; new technology must continually be re-proven in order to gain widespread acceptance. (There does seem to be a trend toward a systems approach in demonstrations, however, which is very beneficial to potential users.) Demonstrations need not only be designed to showcase technical capabilities; the demos need to be cost-effective as well, in order to persuade users to adopt an innovation. Life-cycle costs and cost-effectiveness is often difficult to prove for new product and technologies, however, because they are new. In summary, demonstrations are a collective problem for the industry: the current state of construction technology demonstration and deployment is weak in the fact that there are no "ground rules" for the acceptance of a new technology. Unfortunately, there is no dissemination or

sharing of "lessons learned" or general information on developing, demonstrating, and deploying innovations.

Other voids or weaknesses include liability issues, premature product failures as a result of demos, local issues that need to be addressed for each demo, and the high equipment cost of conducting demonstrations. A credible evaluation is necessary to gain full benefit from the demonstration; however, there is a general lack of knowledge within the industry about organizations with credibility in the evaluation of new technologies. Several strong vehicles for credible evaluations and demonstrations do exist, such as the CPAR program, CALTRANS, HITEC, and its counterpart CEITEC.

**The public and private sectors should work together to develop a mutually agreed upon system that provides risk sharing during demonstration.**

The fact that the government is not allowed to directly participate in the commercialization process by having an established demonstration program was considered a current "gap" by the participants, who felt that current government policies, in general, preclude the use of new innovations. The participants recommended that the government play a more proactive role in technology demonstrations by facilitating (not dictating) them. Current GSA policy (Exec. Order, March '93) that calls for technology demonstration/deployment set-asides and a CRADA/CPAR-like mechanism for partnering should be implemented as mandated. Additionally, the government should share costs, risks, and liabilities of demonstrations. (In current situations, the private sector bears all liability even if the product or technology was developed in collaboration with the government.) The participants also referenced HUD- Ex. Tech. 233 in which an innovative product of a system is insured if it fails, as a potential model for improving the current situation. HUD pays for repair or replacement. In general, there have been several studies conducted on the issue of innovation and technology demonstration and deployment. The group recommended the application of various solutions developed by the Federal Facilities Council, the National Academy of Sciences, and the Construction Industry Institute.

*Recommendations:*

There are several opportunities for public/private partnerships to fill the aforementioned voids and weaknesses. Consortia of industry, academia, and government offer the opportunity for system thinking and bring different perspectives to the issues. Collaborative work should be done on understanding the technology adoption process, and a clearinghouse for transfer of construction demonstration information was proposed. Information and education should be disseminated about all aspects of the process, including identifying a need, investigating, demonstrating, documenting, and using a technology. For example, the group recommended that demonstrations be conducted under the following conditions: the technology fills a need and the market is defined; the demo is cost-shared among stakeholders; and liability is controlled. The group also recommended that advisory boards be established for

demonstrations to increase probability of success and realization of full benefits from the demonstration. For instance, owners' associations could be utilized in determining the design of a demonstration of a new building product or material.

The public and private sectors should work together to develop a mutually agreed upon system that provides risk sharing during demonstration. Improved accessibility of government for collaborations in demonstrating and testing technologies was also recommended. Funding mechanisms that provide for technology demonstrations should be developed or strengthened. Unbiased evaluations of new technologies by stakeholder groups should continue, and existing partnerships such as HITEC/CEITEC, ICBO Evaluation Service, APWA activities, and CPAR should be expanded.

## 6.3 Information Dissemination

*Topic description:*

For research information on advanced materials, products and systems, and facility performance to be useful, it must be readily available to users. Government reports and publications should not be the only means of providing information. Electronic information dissemination through networks that may already exist in the private sector can improve the amount and availability of information available to users.

*Analysis and Recommendations:*

Government, industry, and universities all currently utilize newsletters, email, conferences and meetings, networking, and cross-sector interfaces to disseminate information. Recommendations for improving construction information dissemination include the development of an information access protocol for construction R&D using the World Wide Web. This protocol should include information on construction, construction research, materials, products and systems, laboratories, and facility performance. Both the public and private sectors should support R&D in information dissemination technology, e.g. NIST activities in computer integrated knowledge systems. Topics for further R&D include:

- System architecture: information models; delivery mechanisms; integrated access; and electronic commerce (yellow pages, procurement)
- Enabling information technologies: intelligent agents (search engines); remote data access
- Uniform standards and protocols: acquisition, reassessment, and exchange of information
- Prototype systems: electronic access; materials; facilities.

The group also recommended expanding the use of video conferencing technology for information dissemination, in both active and passive applications. Video conferencing should be used for educational purposes when large audiences are possible, and for information exchange and discussion among small audiences.

## 6.4 Cross-Industry Communication

*Topic description:*

The construction industry is composed of a wide range of interests, including designers, material and product manufacturers, constructors, operators, financiers, regulators, etc. There is a need for improved communication across these fields in general, and particularly during the full life cycle of a facility. Improved communication can help to achieve the National Construction Goals through increased collaboration, improved design and operation of facilities, and reduced litigation.

**There is no impartial government agency to arbitrate competitive regulations.**

*Analysis:*

The group felt that cross-industry communication (including collaboration with government entities) is currently limited by statute functions, mission differences, and organizational differences. Voids include a disconnect in communication among the various players in the construction production chain, as well as a disconnect among the various government agencies involved with construction. For example, in the commercial sector, construction "users" are very involved in the whole construction process, from R&D to marketplace, while in the residential sector, users are not very involved in the process at all. With respect to the government, some agencies are more involved with industry than others. Also, there are differences in agency policies that are confusing and limiting to industry, and there is no impartial government agency to arbitrate competitive regulations. The lack of national evaluation standards makes credible and consistent communication throughout the industry more difficult.

*Recommendations:*

The government should be effective, creative, and responsive to industry, but industry must lead the communication process. For example, a communication strategy/message could be developed with the help of government, but it is industry's obligation to lead this process. This process could be used to revalidate the national construction goals in order to get "buy in" from the bottom up. The government should use its clout as an owner to serve as a facilitator for discussion and central communication throughout industry. Stronger support of construction from the House and Senate subcommittees for civil R&D is recommended.

Specific solutions for solving cross-industry communication gaps/weaknesses recommended by the group are:

- Creation of an issue-based consensus process to bring together private sector and government on specific issues for impartial agreement. Such an effort should be sponsored by a building association or government. Participants which will depend on issues will have to be knowledgeable about and affected by the issues.
- Creation of an advanced building technology council to more rapidly identify, evaluate and introduce new

construction technology into market place. The governments role would be as sponsor/participant/user.

- Creation of a mechanism for interagency coordination, specifically among research labs, mission oriented agencies, to reduce duplication and focus activities. Private sector should be involved to create focus based on user needs.

# 7. Actions Items/Planning the Next Steps

During the small group sessions, the Workshop organizers and participants realized that several common themes and suggestions were emerging throughout the various discussions. The participants used these commonalities to develop a set of action items to be taken by both industry and government to continue the active and productive dialogue fostered at the Workshop and to facilitate future partnering activities. These actions, as suggested by the participants, are described below.

## 7.1 Revised CRADA Protocol

Current CRADA protocols vary by Federal agency. While simple in some cases, the CRADA process can also be cumbersome, complex, and unresponsive to concerns of industry and academia. Additionally, the process of soliciting a CRADA is unpredictable and typically dependent upon finding (or creating) a "champion." Federal agencies should collaborate to create a more uniform, yet flexible and responsive, CRADA mechanism which meets the needs of government, industry and academia. In order to best do this, the agencies should obtain input from the private sector on their experiences with CRADAs: what the strengths and limitations are, what specific improvements should be made, and what agencies have the best model protocol.

A CRADA handbook, or similar educational material, should also be developed and distributed to both the public and private sector. The handbook should discuss the CRADA process from both the government perspective and the private sector perspective, and should detail the steps necessary for developing a successful CRADA. The range of options to address particular issues such as intellectual property rights and liability should also be outlined. The handbook should be developed by representatives from government, industry, and academia to ensure that it addresses the issues of most concern to each sector. Increased knowledge of the CRADA process and the potential benefits are needed in order to expand and strengthen public/private sector collaborations.

## 7.2 Government Market-Driven Research Agenda

The Federal government plays two distinct roles with respect to construction. First, the government is an enabler of R&D by virtue of its network of Federal laboratories and agencies such as the National Science Foundation. These long-standing entities exist to provide technical resources to the Federal agencies and to contribute to our nation's science and technology resource base. The government also plays the role of an "end-user" or consumer of construction technology because it owns and operates a vast network of all types of constructed facilities, both in civilian and military applications.

These two government roles are occasionally out-of-sync with each other. The R&D programs of some mission agencies are developed and executed in a "stovepipe" fashion with little or no cross-cutting assessment of other agencies' activities. Similarly, there is a perception that government R&D is not always in line with user needs (including the government's own). The U.S. does not maximize its return on

government R&D investment because some of the research is narrowly focused, driven by a "paper report" mentality and does not link to other parts of the Federal government with similar - or identical - needs. The government must develop a systematic mechanism for assessing its R&D activities and funding levels, and these should be concurrent with broad national needs. This action will minimize duplication in research activities and will help assure that the government's and the nation's current and future construction-related research requirements are being met. The creation of the C&B Subcommittee was a positive step in the right direction, and its activities should be continued. National (private sector) needs should be considered to the greatest extent possible when determining government R&D agendas, selecting projects, and appropriating funds. Although the private sector is ultimately responsible for technology development and commercialization, government R&D aligned with market needs will aid commercial technology development, and thus economic growth. A formal mechanism for determining these needs should be established.

### 7.3 Develop Community Protocols

Despite its diversity, the U.S. construction and civil engineering community is far more uniform in its research needs than might seem on the surface. Public and private bridges, highways, ports, railroads, and other infrastructure utilize and require much of the same technology. (This technology is then modified by specific application requirements.) Buildings and other structures make use of similar construction materials and products. With the exception of military-specific construction needs, most of the public and private construction technology requirements are largely the same. The public and private sectors should increasingly work together to identify areas of public and private sector need and focus R&D activities on these common problems.

**The R&D programs of some mission agencies are developed and executed in a "stovepipe" fashion with little or no cross-cutting assessment of other agencies' activities.**

Similar to the action stated above, the development of community research and development protocols will contribute to the nation's economic well-being by helping to maximize return on R&D investment. The government and private sector should develop effective partnerships in areas of mutual technology interest and need and with strong market potential or potential for quality of life improvements. This will maximize the return on both sectors' investments. R&D conducted in Federal laboratories and universities many times does not make the transition to the marketplace, remaining instead in shelved research reports. U.S. trade competitors take a more aggressive approach, linking research with demonstration and commercialization. The United States should, and is beginning to, adopt similar measures. As previously mentioned, the Federal government needs to develop a mechanism for identifying national R&D needs and coordinating its resources with those of academia and industry to best meet these needs. Priorities for each sector should then be established, using a public-private sector collaborative process. Only in

this manner will the U.S. be able to utilize its shrinking research resources in a more-effective fashion to meet the future needs of the nation.

**Life-cycle costing must be adopted as the basis of procurement decisions.**

### 7.4 Procure Innovative Technology

Current government procurement regulations drive the construction industry to its lowest common denominator of both cost and performance. The contract delivery system itself is largely to blame. An innovative product or service, which offers superior performance at lower initial or long-term (life-cycle) cost is penalized- or frequently prohibited- from competing in the public procurement arena. Additionally, current government procurement policies are largely focused on lowest bid or first cost; no life-cycle assessment is conducted. Life-cycle costing must be adopted as the basis of procurement decisions in order to promote technological growth and long-term investment in construction. Procurement regulations need to be revised to establish "set-aside" allocations to support innovative technology. The Federal government should continue its efforts in working with the private sector to demonstrate innovative technologies through established programs.

### 7.5 Catalog Federal Research Capability

Currently there is no readily accessible catalog of government construction-related resources: facilities, agencies and research areas, capabilities, points of contact for establishing collaborations, etc. Such a catalog detailing the Federal government's involvement in construction should be compiled and distributed to industry, academia, and government representatives. In general, industry and academia (and perhaps segments of the government itself) are not aware of the quality and extent of Federal resources available to them for potential construction-related collaborative activities. This publication would be a useful tool not only for educating, but also for encouraging collaborations among industry, academia, and government to meet our nation's construction needs.

### 7.6 Technology Transfer

Eventually, successful research and development yields products which appear to be technically-superior and commercially-viable. Successful technology transfer requires a cross-cutting mechanism to accelerate the steps necessary to demonstrate and commercialize innovative technology in the civil engineering and general construction markets. Industry should continue to develop its skills in this process. The principal objective of this recommended model is to expedite construction technology transfer with minimum requirements to create or invest hard assets on the part of the developing organization.

*Technology Transfer Model*

Assuming that R&D has developed products for which the developing organization believes the market potential is sufficient to warrant further effort, the technology transfer model follows the following steps.

A. Establish Advisory Board

The purpose of the Advisory Board is to bring the reality of the marketplace into the development process at an early-enough stage in order to influence significant technical decisions. At minimum, the Advisory Board should consist of a architect, designer, structural engineer, contractor(s), owner/operator and one or more approval authorities (trade, technical and professional organizations (TTPOs), code bodies, regulatory organizations, etc.). The role of the Advisory Board is to provide the development team with critical information on: (1) traditional materials and construction practices, such as strengths, weaknesses, needs, and industry influence factors; (2) performance targets; (3) installed cost targets. The Board should also identify approval authorities, such as TTPOs, standards promulgating bodies, code organizations, and regulatory approval organizations. The Board would work with the developing organization to coordinate demonstration projects and would recommend projects for demonstration. The Board members' wide range of perspective and experience will be invaluable as a continuing "reality check" for all project decisions. The members will serve as liaisons to key industry influence factors and will act as technology advocates within their respective communities.

B. Develop an Evaluation and Approval Plan

A critical technology transfer step is the development of plans for evaluation and approval of proposed products. By and large, the U.S. construction community has few widely recognized approval mechanisms. CERF is taking steps to remedy this situation by establishing a series of innovation centers. These centers, focused in specific areas including highways, infrastructure, and environment, evaluate market-ready products by convening panels of nationally-recognized experts in specific fields who custom-design evaluation and testing plans. Product performance is then measured according to these pre-determined plans and evaluation guidelines. Other organizations such as the ICBO Evaluation Service and National Evaluation Service conduct evaluations of building products. Evaluation centers should be used whenever possible. In most cases, feedback from the evaluation center will identify areas for product improvement, modifications required or other fine-tuning which will require an iterative loop back into the research and/or development phase. Assuming that the evaluation process validates the product, the next step is widespread, but focused demonstration to the prospective market.

**A critical technology transfer step is the development of plans for evaluation and approval of proposed products.**

C. Demonstration Phase

Demonstrations should be conducted on regional and local basis and, in all cases, coordinated through industry

influence factors identified by the Advisory Board or knowledgeable TTPOs. Generally speaking, the number of field demonstrations of the technology will be related to the size and fragmentation of the target market. It is essential that relationships with key industry publications be established during this phase of the project.

D. Promotion & Publicity

The project team should prepare a promotional and publicity plan. Working in concert with the Advisory Board, promotional and publicity efforts should be targeted on industry media and key TTPOs.

E. Education & Training

A continuing education and training package should be developed to introduce the new technology to practitioners. This package should always be created in association with the key TTPOs of the target industry. Education packages should also be widely publicized through the industry media.

F. Commercial Launch

When the above steps have been successfully completed, the product or technology is ready for full-scale commercial launch. Implementing steps should include exhibits at industry trade shows, continuing demonstrations at national, regional and local levels as well as integration into the mainstream activities of key industry trade and professional organizations. In all cases, the process seeks to integrate innovative new technology into the mainstream of the existing industry structure.

**The Workshop and this report serve as a "call to action."**

### 7.7 More Workshops

Additional workshops on construction industry collaborations should be conducted, and they should be designed to attract the interest of as broad of an audience as possible. In the U.S. construction industry, there are literally hundreds of trade, technical and professional organizations, each representing the specialized interests of diverse segments of the construction/civil engineering industry. These TTPOs act as "gate-keepers" for their respective industry segments. Only by soliciting the participation and support of the broad community of stakeholders can the full resources of the industry be mobilized. Workshops, jointly sponsored by stakeholders can help to involve those with problems and those with new technology which can provide the solutions to their problems.

### 7.8 Summary

This Workshop explored the nature of current construction-related collaborations among industry, academia, and government in an effort to educate the industry as a whole about specific mechanisms for collaboration and about future opportunities for partnerships between the public and private sectors. Workshop participants analyzed the strengths and weaknesses of existing mechanisms, developed ideas for new mechanisms, and provided recommendations for improving and strengthening collaboration in the construction industry.

Collaborative efforts between the public and private sectors are mutually beneficial. In addition to leveraging scarce resources such as financing, equipment, and specialized expertise, effective collaboration can help maintain our nation's technological leadership by minimizing duplication, maximizing return on R&D investment, and promoting technological innovation to meet national needs. The construction industry plays a critical role in our nation's economy—employing ten million people and contributing 13% of the GDP. Continued and increased collaborations among government, industry, and academia in construction will not only contribute to the future technological competitiveness of the industry, but will also help to ensure a strong U.S. economic future. This Workshop was the beginning of what should continue to be an active dialogue between the public and private sectors on construction-related partnering opportunities. More important, however, the Workshop and this report serve as a "call to action" to bring such opportunities to fruition. The seven action items outlined in this section are key initial steps in accelerating the effort to foster public-private collaboration. Readers of this report are encouraged to become involved in one or more of these activities. Collaborations will only result in benefits to the industry and the nation if they are actively pursued and executed.

# Appendix A: Workshop Agenda

# CONSTRUCTION INDUSTRY COLLABORATIONS WORKSHOP

**Sponsored by the Construction and Building Subcommittee, National Science and Technology Council**

**Coordinated by the Civil Engineering Research Foundation**

**Sheraton National Hotel**
**Arlington, VA**

**April 2-3, 1996**

## AGENDA

**Day One: Tuesday, April 2**

| | | |
|---|---|---|
| 8:00 am | Breakout Session Leader Orientation | |
| 8:30 am | Registration/<br>Viewing and Discussions: Agency Exhibit Displays<br>*Continental Breakfast Will Be Provided* | |
| 9:30 am | Welcome | Arthur H. Rosenfeld<br>Science Advisor, Energy Efficiency and Renewable Energy<br>Department of Energy |
| 9:40 am | Opening Remarks | Harvey M. Bernstein<br>President<br>Civil Engineering Research Foundation |
| 9:50 am | Keynote Address | Mary L. Good<br>Under Secretary for Technology<br>Department of Commerce |
| 10:20 am | Introduction of National Construction Goals<br>Objectives and Structure of Workshop | Richard N. Wright<br>Director<br>Building and Fire Research Laboratory<br>NIST |
| 10:40 am | Overview of Federal Capabilities | Donald J. Leverenz<br>Assistant Director of Research and Development (Military Programs)<br>U.S. Army Corps of Engineers |
| 11:00 am | Break | |
| 11:15 am | Workshop Strategy | Gary Bates<br>Workshop Facilitator |
| 11:30 am | Success Stories: Case studies of successful collaborations<br>*Each panelist will present his/her story by explaining the benefits of collaboration, barriers overcome, roadblocks that remained and what should/could be done to overcome them in the future. Questions from the audience and panel discussion will take place after all presentations have been completed.* | Panel of Private Sector Participants |
| 12:30 pm | Luncheon/<br>Viewing and Discussions: Agency Exhibit Displays | |

(continued)

# CONSTRUCTION INDUSTRY COLLABORATIONS WORKSHOP

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## AGENDA

**Day One: Tuesday, April 2 (continued)**

| | | |
|---|---|---|
| 2:15 pm | Intellectual Property Rights:<br>A Challenge in Developing Partnerships | Terry Lynch<br>Licensing/CRADA Officer<br>NIST |
| 2:45 pm | Overview of Breakout Sessions | Gary Bates |
| 3:00 pm | First Breakout Session: | |

**Mechanisms for Collaboration**

*The first breakout session focuses primarily on the structure of different collaboration mechanisms. The session will likely be highly informative in nature, as it is anticipated that many participants will be learning about some of these mechanisms for the first time. For each topic, the breakout session teams will discuss the strengths and weaknesses of the specific partnering mechanisms. Critical collaboration issues (e.g., intellectual property, management issues, revenue stream, etc.) that are relevant to each mechanism will also be discussed. The session participants will then brainstorm and discuss potential ways of improving these mechanisms, as well as generate ideas for new collaboration mechanisms.*

- Use of government facilities and capabilities and role of government as consultant/assistance provider
- Commercialization of government lab technologies
- Joint research agreements
- Jointly-sponsored research centers
- Research consortia and large-scale industry-wide network programs

| | | |
|---|---|---|
| 4:45 pm | Breakout Groups Prepare Summaries | |
| 5:00 pm | Breakout Group Presentations to Full Audience | Gary Bates |
| 6:00 pm - 7:30 pm | Evening Mixer/ Exhibit Display by Government Agencies<br>*One-on-one discussions with potential collaborators* | |

Dinner on your own

(continued)

# CONSTRUCTION INDUSTRY COLLABORATIONS WORKSHOP

**Sponsored by the Construction and Building Subcommittee, National Science and Technology Council**

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## AGENDA

**Day Two: Wednesday, April 3**

| | | |
|---|---|---|
| 8:00 am | Viewing and Discussions: Agency Exhibit Displays<br>*Continental Breakfast Will Be Provided* | |
| 9:00 am | Overview of First Breakout Session/<br>Preview of Second Breakout Session | Gary Bates |
| 9:30 am | Second Breakout Session:<br>**Opportunities for Partnerships**<br>*The second breakout session will focus more on brainstorming about improving the public sector's role in collaborative activities. Each session will answer the question: what role(s) should the government play in collaboration with the construction industry to fill existing voids? Each session team will discuss potential government roles and public/private sector working relationships for their topic.*<br>• Research and pre-commercial technology development<br>• Technology demonstration and deployment<br>• Information dissemination<br>• Cross-industry communication | |
| 11:15 am | Breakout Groups Prepare Summaries | |
| 11:30 am | Breakout Group Presentations to Full Audience/<br>Working Lunch | Gary Bates |
| 12:30 pm | Action Items/Plans for Next Steps | Gary Bates |
| 1:30 pm | Workshop Adjourned<br>*Agency representatives will be available for informal discussions until 2:00 pm.* | |

# Appendix B: Construction Industry Collaborations Workshop Exhibitors

# CONSTRUCTION INDUSTRY COLLABORATIONS WORKSHOP EXHIBITORS

**Air Force, Wright Laboratories/FIVCF**
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Tyndall AFB, FL 32403
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**Department of Agriculture Forest Service**
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202-219-8136 fax 202-219-6599

**Department of Transportation**
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McLean, VA 22101
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**Department of Veterans Affairs**
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Kate McManus
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**National Institute for Occupational Safety and Health Centers for Disease Control and Prevention**
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# Appendix C: Federal Agency Capabilities

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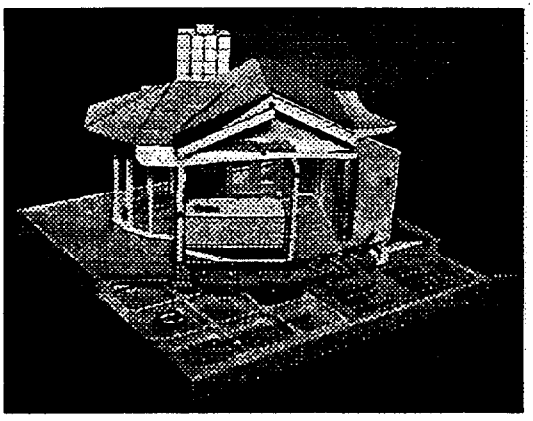
*APPENDIX C: Federal Agency Capabilities*

# U.S. Department of Agriculture
# Forest Service
# Forest Products and Harvesting Research



*This model house depicts the use of new recycled wood and paper products for housing. Use of recycled products has the potential to conserve resources, reduce land-fills, provide additional supplies of construction materials, and create jobs.*

## 1. MISSION

The USDA Forest Service's natural resource stewardship responsibilities include ensuring the wise and efficient use of our nation's forests. As part of that responsibility, the Forest Service conducts research to develop technology that helps meet America's growing demand for forest products, conserve our Nation's forests, and improve the environmental sensitivity of forest products manufacturing.

## 2. KEY ACTIVITIES/INITIATIVES AND OPPORTUNITIES FOR COLLABORATION

To develop processing technologies that increase efficiency, minimize environmental impacts, and improve utilization of wood wastes

To provide a technical basis for performance characteristics of wood products used in housing.

To identify test procedures and criteria for the development of codes and standards for new wood products.

To facilitate the implementation of new technologies with industrial partners

## 3. MECHANISMS FOR GOVERNMENT-INDUSTRY COLLABORATION

The Technology Transfer Act of 1986 (TT Act) opened the door for the Forest Service to be more active in transferring technology to industry. Increased cooperation between government and industry also has the added advantage of melding the strengths of both sectors. The Forest Service Patent Program provides an important mechanism to actively market technology created by the agency, thus meeting goals established by the TT Act.

Through the use of Cooperative Research and Development Agreements (CRADAs), the Forest Service Patent Program enhances the opportunity to transfer and successfully market Forest Service technology to industry. The CRADA's and the ability to license patented technology provide

increased opportunities for numerous partnerships that would not otherwise exist. Partnerships between government, private sector, and non-profit organizations have brought together technical and market expertise to make the process work. Incentives of the patenting and licensing process are: (1) the exclusivity of a patent; (2) recognition given to inventors; and (3) income from licensed patents. The Patent Program has already proven to be successful, as evidenced by a rapid increase in numbers of both CRADAs and patent licenses involving FS scientists.

## 4. RESOURCES FOR POTENTIAL COLLABORATORS

The USDA Forest Service is uniquely qualified to lead a comprehensive research program requiring the involvement of government, industry, and academic partners. The Forest Products Laboratory (FPL) has the expertise and facilities for researching and developing housing components from recycled wood and wood fiber. Recycling research at FPL began over 40 years ago, to help conserve our Nation's resources. FPL also plays a critical role in the development of engineering design standards and building codes, with over 80 years of wood construction engineering design and performance evaluation experience. While the primary location of the research will be at FPL, scientists from several other Forest Service Laboratories and from universities will be an integral part of the program. State and Private Forestry, working closely with researchers, will concentrate on marketing and transferring recycling technology through its well established network of partners at the Federal, state, and local levels.

## 5. CONTACTS

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Tel: (608) 231-9200

Hao C. Tran, Staff Specialist, Forest Products and Harvesting Research,
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Washington, DC 20090
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# Department of Commerce

**Building and Fire Research Laboratory**
**National Institute of Standards and Technology**
**Gaithersburg, MD 20899**

## Mission:

NIST's Building and Fire Research Laboratory (BFRL) is dedicated to improving the life cycle quality and economy of constructed facilities. Its performance prediction and measurement technologies enhance the competitiveness of U. S. industry and public safety. The laboratory studies structural, mechanical, and environmental engineering, fire science and fire safety engineering, building materials, and computer integrated construction practices.

## Key activities/initiatives where industry collaboration is welcome

BFRL welcomes collaboration in all five of its technical divisions and its Office of Applied Economics. The division activities are as follows:

**The Structures Division:**

- provides the technical basis for improved structural, earthquake, and wind design criteria;
- conducts, field and analytical research in structural engineering, including investigation of important structural failures, characterization of building loads during construction and service, and structural response analysis
- produces evaluation methods and criteria leading to safer and more economical construction practices; and
- determines engineering properties of soils and foundations and develops non-destructive evaluation methods and criteria for increasing structural properties.

**The Building Materials Division:**

- conducts analytical, laboratory, and field research, including the development of methods to measure and predict service life of construction materials; and
- develops technical bases for improving criteria and standards used to evaluate, select, use, and maintain construction materials and for improving tools to make decisions in selecting construction materials, including high-performance concrete and coatings.

**The Building Environment Division:**

- develops data, measurement and test methods, and modeling techniques to determine building air leakage, the performance of the building envelope and its insulation systems, and the release, movement, absorption of indoor air pollutants, the performance of building mechanical and electrical equipment, and the quality of the indoor environment; and
- develops performance criteria, interface standards, and test methods to help the nation's building industry make better use of computer-aided design hardware and software.

**The Fire Safety Engineering Division:**

- develops and demonstrates the application of analytical tools to building fire problems and quantitative prediction of threats to people and property from fires, as well as the means for assessing the accuracy of the models;
- develops techniques to predict, measure the behavior of, and mitigate the impact of large fires;
- maintains and advances the Fire Research Information Service (301-975-6860); and
- operates BFRL's large-scale fire test facility.

**The Fire Science Division:**

- produces principles, metrology, data, and predictive methods to evaluate the smoke components in flames and the burning of polymeric materials;
- generates science and predictive methods for the development of high-performance fire detection and control systems; and
- develops understanding of and information about new fire suppressants and their use.

**The Office of Applied Economics:**

- develops standard methods of economic analysis for evaluating buildings and construction;
- measures economic impacts of building research programs,
- develops user-friendly decision-support software for the economic analysis of new technologies and processes; and
- provides classroom instruction and educational materials (manuals, problem sets, and videos) on how to perform economic analyses in building and construction.

## Specific Mechanisms Designed to Foster Government-Industry Collaborations

BFRL conciders direct interaction and collaboration with the private sector critical to a successful research program. Available collaboration opportunities include:

- laboratory visits to share information
- cooperative research and problem solving, access to unique resources
- cooperative proprietry research to achieve customer's technology mission, with industry partner holding rights to intellectual property
- guest researcher assignments for collaborative research
- research consortia to solve industry-wide problems
- licencing inventions

## Resources Available for use by/with Potential Collaborators

The National Institute of Standards and Technology (formerly the National Bureau of Standards) has been involved in building and fire research for over 90 years. The staff of BFRL totals over 170 with expertise in mathmatical modeling, high-speed instrumentation, non-destructive testing and diagnostics, information technologies, modeling environmental processes, and advanced fire detection and suppression. The laboratory has unique facilities which include:

- Large-scale structures test facility with a 53MN (12-million pound) universal testing machine that test components 17.7 m (58 ft) in height
- Tri-directional structural test facility which can apply forces or displacements in three directions simultaniously on structural components up to 3.4 m (11ft) high and 3.1 (10 ft) long or wide.
- Guarded hot plate for measuring the thermal resistance of insulation or other low density materials up to 400 mm (15 in) thick and 1 m (39 in) in diameter
- Callibrated hot box which uses an environmental and climatic chamber to simulate indoor and outdoor conditions.
- Cone Calorimeter used for measureing the rate of heat and smoke release bu burning materials.
- Lateral ignition and flame spread apparatus used to measure properties of vertically oriented sample under uniform radiant heat flux of 6.5 W/cm$^2$.
- Large burn facility. This multi room facility is used for full scale experimental verification of mathmatical models. Two large heat-release rate calorimeters have capacities of 1/2million W and 7 million W.
- Environmental chambers. BFRL has one large (14.9m x 12.8m x 9.5m) and six smaller environmental chambers with temperatures ranges of -40C (-40F) to 65C (150F).
- Controls laboratory which incorporates a computerized energy monitoring and control system used for fundamental research on HVAC control systems.
- Microstructure laboratory equipped with digital scanning electron microscope with X-ray powder diffractometer and petrographicand stereo microscopes. The facility is used for microstructural characterization of cement clinkers, high-performance concrete, and mortars, and characterization of insulation and protective coatings.
- Outdoor energy conservation laboratory A passive solar house and six one-room buildings constructed of different materials to test the thermal performance of solar building features.

## Contacts:

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# Department of Defense
# Defense Research and Engineering
# Washington, D.C.

## Civil Works Research & Development Program

### Mission:

DOD administers the Civil Works (CW) Research & Development (R&D) program to provide solutions to problems related to the Corps of Engineer's Civil Works Program. The CW R&D is highly applied research utilizing products and techniques developed by industry and universities and adapting them to civil works needs. Research in six areas of the Civil Works R&D program contribute to the goals of the Construction & Building R&D Program.

### Major Activities Contributing to the Construction and Building Program

- Materials Research
- Coastal Structure evaluation and design
- Flood control structures research
- Repair, evaluation, maintenance & rehabilitation
- Construction productivity research
- Earthquake engineering research

## Military Research & Development Program

### Mission:

The primary goal of the DOD civil engineering research program is to support the national security objectives of the nation by conducting research to enhance the life cycle performance of the infrastructure required to provide an efficient and cost effective power projection platform for the armed forces. The DoD Reliance program has eliminated redundant military research and development programs and capabilities and has increased interdependence among the military services for Civil Engineering Science and Technology R&D. Five Civil Engineering Reliance R&D focus areas contribute to the goals of the Construction & Building R&D program.

### Major Activities Contributing to the Construction and Building Program

- Conventional facilities
- Airfields and pavements
- Fire fighting
- Ocean and waterfront facilities/operations
- Critical airbase facilities/recovery

### Contact

Thomas Rutherford, Office of the Under Secretary of Defense for Research and Engineering
Tel: 703-756-0997 Fax: 703-756-7648 E-mail:ruthertr@acq.osd.mil

# United States Army Corps of Engineers
# Summary of Laboratory Facilities

## U.S. Army Construction Engineering Research Laboratories (USACERL)
## Champaign, IL

The U.S. Army Construction Engineering Research Laboratories (USACERL) is an Army Corps of Engineers Research and Development (R&D) Laboratory in Champaign, IL. USACERL's mission is:

To perform infrastructure and environmental sustainment research, development, studies and technical assistance leading to a quality trained and ready Army; to set the standard in preserving and protecting its land water and natural and cultural resources; to repair, maintain and rehabilitate civil works facilities.

To perform research and development for enhancing engineer capability to deploy rapidly and to sustain a full range of military operations.

To fulfill this mission USACERL integrates complementary, diverse, or non-coordinated technology-based R&D programs and is equipped with state-of-the-art facilities with special assistance programs to meet customer needs. Following are some of USACERL's capabilities:

### EQUIPMENT AND FACILITIES

Triaxial Earthquake and Shock Simulator (TESS) - A unique dual-mode shock and vibration test facility. The TESS, in its biaxial mode, simulates a wide range of transient shock vibrations typical of military applications requiring large accelerations over a wide frequency range with moderately heavy test specimens. In the triaxial mode, it can simulate a variety of vibration environments including earthquakes and random vibrations, as well as logsweep and resonant researches.

Heating, Ventilating, and Air-Conditioning (HVAC) Test Facility - Can be configured to replicate a variety of HVAC system types including single or dual-duct and variable air volume (VAV) or constant volume. It has six distinct sections: 1) air distribution, 2) hot water distribution, 3) chilled water distribution, 4) four separate zones or rooms, 5) HVAC controls, and 6) data acquisition. The facility permits researchers to investigate HVAC system and component efficiency improvements and improvements in HVAC central strategies.

Paint Technology Center - Supports the Corps painting activities by offering assistance through consultation, specification testing, training, research, and inspection or management aids.

Ion-Plating System for Corrosion-Resistant Coatings - State-of-the-art physical vapor deposition capability that can also check the quality the quality of shielded materials.

Scanning Electron Microscope with EDX Capability - Has 50 Angstroms resolution (400,000 times magnification) enabling research at the subparticle level.

Acoustics Lab: Impulse Noise Technology - The Noise Monitoring System reduces complaints, mitigates noise, and documents compliance.

Interaction with the University of Illinois - USACERL has a unique relationship with the University of Illinois at Urbana-Champaign (UIUC). This relationship includes the exchange of personnel and information in related research areas.

Some of the facilities available to CERL are Beckman Institute, Hazardous and Toxic Waste Laboratory, National Center for Supercomputing Applications, and the Geographic Modeling System.

USACERL also works closely with UIUC Department of Civil Engineering in its capacity as an advanced Construction Technology Center. Research conducted under the Center forms the basis for part of the exploratory development work done at USACERL. USACERL assists UIUC in identifying the Army's research priorities for the University Research Initiative program.

## U.S. Army Cold Regions Research and Engineering Laboratory, (CRREL) Hanover, NH

The U.S. Army Cold Regions Research and Engineering Laboratory (CRREL), situated in Hanover, New Hampshire, focuses on the special physical science, environmental, and engineering challenges needed to operate in cold regions and serves as the federal government's center of excellence for cold regions research. CRREL has an aggregation of low temperature laboratory and experimental research facilities not found anywhere else in the world. These facilities are nationally and internationally recognized for their unique capabilities and are often used by industry and academia because of the unique capability they represent.

### EQUIPMENT AND FACILITIES

Forming the center of CRREL's main laboratory building is its 26-unit cold room complex. The temperature in these refrigerated rooms can be dropped to as low as -36°C and are used for the conduct of low-temperature basic research on snow, ice and frozen ground, and small-scale experiments such as concrete admixture performance, expedient low temperature chemical decontamination, and thawing soil stabilization.

The6-8x10³m² Ice Engineering Facility (IEF) supports research on winter navigation ice structure interactions, ice jam flooding, and performance of surface vessels and submarines in ice. The IEF includes three research areas: (1) a refrigerated research area (24.4 m by 148.8m) where large-scale physical models of sections of rivers and lakes can be built and operated to simulate natural conditions and test scale models of remedial measures, (2) The 9.1m wide, 2.4m deep and 36.6m long test basin operates at any temperature between 18°C and -23°C that allows replication of conditions to test and monitor ice forces, (3) The 36.6m long refrigerated flume is used for river channel analysis and ice formation studies.

The 2.7x10³m³ Frost Effects Research Facility (FERF) is a refrigerated geotechnical research facility, the largest of its kind in the world. Full-scale controllable freeze-thaw tests can be conducted on pavements, soils, and structures.

The Civil Works Remote Sensing/Geographic Information Systems Center is involved in oil spill and flood mapping and large area environmental assessments critical to emergency response efforts.

CRREL has special purpose ice test facilities, analytical chemistry laboratories, clean rooms, low temperature materials laboratories, a research permafrost tunnel in Fox, Alaska, and has access to a 133 acre permafrost research site on Fort Wainwright, Alaska. CRREL also operates a field office at Fort Wainwright, Alaska that provides direct liaison to military units in Alaska and the Pacific Rim (Korea and Japan) for cold regions operations as well as support to research activities in Alaska.

## U.S. Army Topographic Engineering Center (TEC)
## Alexandria, VA

TEC is the Army's center for geospatial technology research and development. TEC's primary technologies relate to accurate, realistic, and timely hardcopy map products, field guides, and softcopy visualization of the earth's surface for both military and non-military applications. Strong emphasis is placed on development of faster and more accurate ways to describe, characterize, and analyze the surface of the earth through research in remote sensing, geographic information, global positioning, topographic, and information technologies. Major areas of research include the following:

Research in creation of geospatial databases from maps, imagery, survey data, and from both remote and ground sensor information. This includes research in the development and use of spectral data.

Research in terrain analysis, including the development of military mobility and intervisibility models, and techniques for interposing environmental and terrain characteristics using geostatistics.

Research in rapid mapping technology to increase the speed, accuracy, and resolution of topographic information for both military and civil applications. This thrust includes research in image classification using wavelets and neural networks, and in automated image recognition and compression. It also includes research in terrain visualization, including modeling and simulation for use in both training and operations.

### EQUIPMENT AND FACILITIES

TEC's research and development capabilities include the following facilities and equipment: Spectral Research Facility; Spectral Exploitation Facility; Global Positioning and Survey Engineering Laboratory; Battlefield Visualization Test Bed; Image Exploitation System; Fourier Communication Technology Satellite (ACTS) Ground Station; Environmental Support Laboratory; Image Digitizing System; Image Processing/Geographic Support System; Multispectral Imagery Processor; GIS, GPS, remote sensing, photogrammetric, and CAD software; and special high resolution printers.

## U.S. Army Engineer Waterways Experiment Station (WES)
## Vicksburg, MS

WES is the largest Civil Engineering/Environmental Quality R&D complex in the Nation and is the Tri-Service lead laboratory in the civil engineering areas of airfields and pavements, survivability and protective structures, and sustainment engineering. Primary research and development missions encompass weapons effects; fighting positions; terrorist threat protection; obstacle creation and reduction; fixed facility camouflage, concealment, and deception, vehicle/terrain interaction; military hydrology; lines of communication, construction, and repair; airfields and pavements; coastal engineering; coastal oceanography; *littoral* processes; hydraulic engineering; flood control and navigation; dynamic modeling and simulation; environmental impact; groundwater modeling; wetlands processes; environmental site characterization;

ecosystem processes; reservoir, riverain, estuarine, and coastal water quality; mobility analyses; seismic response of structures; earthquake engineering; dredging and dredged material disposal; natural resources management; concrete technology, structural dynamics; and geotechnical engineering.

## EQUIPMENT AND FACILITIES

WES has an unparalleled combination of experimental and computational facilities for research in hydraulic, geotechnical , structural, environmental, and coastal engineering, and information technology. Some of the more significant facilities are:

Civil and Environmental Engineering Centrifuge Test Facility. Operational in spring '96 the world's most powerful (1,260 g-tons) and technically diverse centrifuge has a 6.4m radius with a maximum payload capacity of 9,000 kg. Multiple chambers with specialized vibrator, detonation system, hydraulic interfaces, and freezing capabilities facilitate studies addressing
deep foundations, pollutant migration, explosion simulations, freeze-thaw effects, and dynamic loading produced by explosions and earthquakes.

Hazardous and Toxic Waste Research Center (HTWRC) (1579 $m^2$). Only DOD-permitted (RCRA) facility to conduct large volume HTW research, development, test, and evaluation. EPA recognizes the HTWRC as the Nation's premier facility.

Fate and Effects R&D Center (2787 $m^2$): Complete experimental radioisotope, microbiology, toxicity, and instrumentation laboratories for contaminant fate and effects on ecosystems.

DoD High Performance Major Shared Computing Center (5110 $m^2$): includes CRAY C90 and Y-MP systems which provide the most powerful scientific and engineering capability in DoD. Includes a $4.1M computer graphics laboratory to identify and develop innovative methods of interpreting large data sets from modeling/simulation, field data collection, and Computer Aided Design and Drafting (CADD) applications.

Airfields & Pavements Research Center (2323 $m^2$): State-of-the-art facility containing the DoD unique Joint Sealant Laboratory and an Automated Data Acquisition System for acquiring rheological data on creep, strength, resilient moduli, and fatigue of a variety of paving materials.

Soils Research Center (929 $m^2$): The largest soil mechanics research facility in DoD, it has a loading capability of $1.1 \times 10^6$N on triaxial specimens up to 0.38m In diameter.

Mass Construction Materials Laboratory (1858 $m^2$): A concrete research and development facility for determining physical, chemical, and mineralogical properties of concrete and other construction materials as well as the structural response of subscale models.

Full-Scale Aircraft Loading Facility: Simulates aircraft loading with different wheel loads and gear geometry applied to full scale constructed test pavements; response and performance data for development of new design models and behavior theories; current fighter and transport aircraft simulators.

Projectile Penetration Facility: Unique to DoD, this facility enables investigation of antipenetration shielding technology techniques employing geologic and manmade structural materials against a wide variety of projectile threats.

Coastal Facilities: Approximately 37,160m² under roof for 3-D high-precision costal experiments. Contains over 259m of spectral wave generators (including the 90-ft long Directional Spectral Wave Generator) designed to reproduce waves up to 0.6m in height.

Field Research Facility: Duck, NC (): Recognized worldwide for cooperative field experiments in coastal and near shore processes; 600 m concrete and steel pier, one mile of beachfront, full suite of installed coastal processes instrumentation, special purpose beach and amphibious vehicles, etc.

Riprap Test Facility: The largest curved channel test facility of its kind, used for study of effects of curves on velocity of flow, specifically aimed at developing design criteria for riprap protection.

Mobility Instrumentation Facility: 2787 m² complex for conducting research and investigations in the areas of cross-country mobility, trafficability, and terrain data acquisition. The research requires complex design and fabrication of real-time data collection and analysis hardware unique to quantifying the performance of all types of wheeled, tracked, and amphibious military vehicles. A 1,300 m² annex is optimally structured to support modeling and simulation capabilities in distributive interactive simulations and virtual prototyping in support of battlefield automation.

Environmental Chemistry Laboratory: 650 m² state-of-the-art analytical laboratory supporting the total spectrum of DoD environmental research, development, and technical assistance requirements.

Aquatic and Wetlands Ecosystem Research Center: 929 m² facility provides capability to evaluate the impact of DoD activities on aquatic and wetland ecosystems, including impacts on threatened and endangered species, and wetland identification, delineation, and evaluation.

# U.S. ARMY CORPS OF ENGINEERS
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# Department of Energy
# Office of Building Technology
# Washington, D.C. 20585

## MISSION:

The building sector, including both residential and commercial buildings, currently uses 30 quadrillion BTU's of primary energy annually. This is 35 percent of total U.S. energy consumption, and includes 65 percent of all electricity used in the U.S. Federally owned facilities represent approximately 2 percent of U.S. building stock. The mission of Office of Building Technologies (OBT) is to limit the expected increase in building sector energy consumption by improving energy efficiency and expanding the use of renewable energy in buildings. Recent analysis has shown that the growth in demand for energy services in buildings can be met without increasing total energy use. Increased emphasis in market-pull activities has been the result of the Energy Policy Act of 1992 and the Climate Change Action Plan of 1993.

## MAJOR ACTIVITIES:

• OBT conducts a comprehensive research program designed to develop, demonstrate and, if appropriate, commercialize advances in energy performance of major building components including thermal insulation systems, windows, and heating and cooling equipment.

• Additionally, OBT conducts a program that focuses on the activities of market-pull and market transformation of energy efficient buildings systems. This includes many of the activities recently authorized by Energy Policy Act and the Climate Change Action Plan: for example, "Rebuild America" is a program directed at upgrading the energy performance of the existing stock of commercial buildings. The "Design Tools" program focuses on the market delivery of tools that will allow for full consideration of energy options in the design of our future buildings.

• OBT develops and promotes building energy codes, appliance and equipment standards for residential and commercial buildings.

Through its Office of Federal Energy Management DOE leads the Federal government's drive for increased energy efficiency and renewable energy utilization in its own facilities and vehicle fleets.

## Contacts:

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# U.S. Department of Energy
# Albany Research Center

## Mission:

The DOE's Albany (Oregon) Research Center (ALRC) provides stewardship to the Nation's minerals resources by conserving materials produced from minerals through a cost-shared, cooperative research program. The ALRC conducts research efforts to determine factors which limit service life of materials in industrial, structural, and engineering application and provides solutions through new materials technology.

## Major Activities Contributing to the National Construction Goals:

- Use basic science to study and solve a wide variety of industrial-related degradation problems. Current research emphasizes atmospheric corrosion of the infrastructure and construction materials, especially in marine environments.

- Aid in selection of the most cost-effective engineering materials for energy production, plant construction, mining, minerals processing and manufacturing equipment, in infrastructure and other structures, and in transportation vehicles.

- Improve product performance and reduce wastage in industries where the grinding, milling and pumping of abrasive materials are employed by improving the mechanical properties through intelligent design of alloys and control of alloy solidification behavior.

## Mechanisms to foster government-industry collaboration:

Many Cooperative Research and Development Agreements (CRADA's) have been established to allow the transfer of commercially useful technology to industry in order to share the costs, tasks, and outcomes of research.

## Resources available:

- Wear Test Facility
- Electrochemical Corrosion Testing Facility
- Vacuum arc and induction furnaces
- Materials Processing and Evaluation Facility including fabrication, metallography and mechanical testing laboratory
- 0.5 meter diameter, 1MW Cupola furnace
- 1MW Electric Arc Furnace
- Extensive machine shop and welding capability

## Contacts:

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# Department of Health and Human Services
# National Institute for Occupational Safety and Health
# Centers for Disease Control and Prevention, Atlanta, GA 30333

**Mission:**

NIOSH is the federal Institute responsible for conducting work-related research and making recommendations to prevent illnesses and injuries. The Institute has a special focus on construction workers, with research addressing a wide range of construction-related hazards such as silica exposure, dermatologic conditions, ergonomics, falls, injuries, and exposure to lead.

**Major Activities to Reduce Construction Hazards**

- Conduct research and provide recommendations to employers, workers and agencies
- Evaluate potentially hazardous working conditions at the request of employers or employees
- Develop control technology solutions for problems of worker exposure
- Disseminate recommendations for preventing disease, injury, and disability
- Provide education and training for occupational safety and health professionals

**Contact:**

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Pittsburgh Research Center, National Institute for Occupational Safety and Health
The Pittsburgh Research Center was established in 1910, with the creation of the Bureau of Mines. It is located in the Bruceton Research Center complex. The Center has evolved into one of the world's foremost mining research establishments, pursuing an aggressive, innovative program to promote the safety and health of the Nation's miners. Today, the Pittsburgh Research Center employes specialists trained in many different disciplines, including engineering, geology, physics, chemistry, industrial hygiene, psychology, and computer science. The Center has gained prominence in many technical areas and is home to some unique facilities which include:

The Experimental and Safety Research Coal Mines. These two mines with four miles of tunnels are used for conducting research on preventing mine fires and explosions as well as providing a realistic environment for testing new equipment and technology before transfer to industry. The Mining Equipment Test Facility houses a variety of equipment including the Strategic Structures Testing Laboratory--a computer controlled hydraulic press capable of exerting 13.3 x $10^6$N of vertical force and 3.56 x $10^6$N of horizontal shear on structures up to 6 meters high. The press is most often used for evaluating mining roof support structures. The Wire Rope Research Laboratory contains fatigue bending and tensile test machines for evaluating hoist ropes used for transporting personnel and materials in shaft mines.

The Lake Lynn Laboratory, 80 kilometers south of the Bruceton complex, is a 1.6 x $10^6 m^3$ surface and underground facility for the study of large-scale explosion and fire phenomena. The extensively instrumented tunnels can collect temperature, pressure, velocity and video data in the midst of these destructive events.

**Contact:**
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Spokane Research Center, National Institute for Occupational Safety and Health
The Mine Hoisting and Ore Pass Test Facility in Spokane, Washington consists of a 1/5 scale ore skip (bucket), a 21 m tower that extends underground to simulate the mines shaft, an ore pass and loading gate system, and an automated motor and gate controls for running cycle tests of the hoist. The facility was developed to test automated loading concepts and new sensors for monitoring rope loads, ore level and flow, and shaft alignment.

**Contact:**
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# Department of Housing and Urban Development
# Policy Development and Research, Washington D.C. 20410

## Mission:

The Office of the Assistant Secretary for Policy Development and Research is responsible to the Secretary of Housing and Urban Development for overall Departmental policy, program evaluation and research. The Division of Affordable Housing and Technology conducts research and analysis on the production and supply of housing and on the physical and technical aspects of community development. The Division addresses all physical, structural, developmental technology, regulatory, and related issues needed to support the Department's commitment to ensure decent, safe, and sanitary housing in a suitable living environment for all Americans.

## Major Activities Contributing to the Construction and Building Program:

- **Expanding Housing Opportunities for Low and Moderate-Income Families**

Research and policy analysis to expand affordable housing opportunities by reducing the initial and operating cost of housing and to expand the affordability of new and rehabilitated housing supplied by both the private and publicly-assisted market.

- **Empowering Communities**

Technical, developmental and related regulatory research to assist in the physical redevelopment of communities.

- **Opening Housing Markets**

Research to develop new legislative and regulatory tools to ensure that new development provides equitable access to jobs and housing for lower-income and minority families.

- **Meeting Key Administration Objectives**

Research that permits the integration of other major social objectives such as environmental protection and hazard prevention into the programs of the Department and into housing production without sacrificing housing affordability and viable urban redevelopment.

## Contact:

David Engel, Director Affordable Housing Research and Technology Division,
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# Department of Interior
# Bureau of Mines, Washington D.C. 20241

## Mission:

As the Nation's principle conservation agency, the DoI has responsibility for most of our nationally-owned public lands and natural resources. The U.S. Bureau of Mines (USBM) is the primary organization within DoI dealing with issues related to building and construction. The USBM's Center for Materials Partnership conducts research leading to improved materials that offer resistance to corrosion, wear, and breakage and that can be substituted for materials that are hazardous to health and safety. Materials performance and service life prediction technologies provide the basis for economical and environmentally sound solutions to the Nation's materials needs. Materials used in the construction of infrastructure are an important component of the Center's research.

In support of the goals and efforts of the Subcommittee on Construction and Building, the U.S. Geological Survey (USGS) provides valuable input into the location and site selection of various construction and building projects, as well as into potential hazards and environmental impacts. Its mission is to provide scientific data concerning earthquakes, floods, erosion, ecosystem impacts, and energy and water availability.

## Major Activities to Reduce Deterioration of Construction and Building Materials

- Provide expertise on environmentally safe and stable construction materials (e.g., Monticello roof restoration).

- Map corrosivity of coastal environments and effects of microclimates in Pacific Northwest.

- Develop atmospheric corrosion model for predicting performance of structural metals (e.g., National Acid Precipitation Assessment Program).

- Evaluate effects of environment on OR Newport is currently being arc-sprayed with zinc to service life of construction materials an form anode for impressed-current cathodic protection and structures, including coastal bridges..

- Analyze construction material failures bridge in sheltered and exposed locations to assess (e.g., phosphate slurry pipeline).
- Develop and refine impressed current cathodic protection systems for steel-reinforced concrete bridges.

## Contact:

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# U.S. Department of Labor
# Occupational Safety and Health Administration
# Washington, D.C. 20210

## Mission:

The mission of the Occupational Safety and Health Administration (OSHA) is to save lives, prevent injuries and protect the health of America's workers. To accomplish this, federal and state governments must work in partnership with the more than 100 million working men and women and their six and a half million employers who are covered by the Occupational Safety and Health Act of 1970 (OSHA Act). OSHA and its state partners have approximately 2100 inspectors, plus complaint discrimination investigators, physicians, educators, standards writers, and other technical and support personnel spread over more than 200 offices throughout the country.

Because construction is such a hazardous occupation, the OSHA Office of Construction and Engineering was created in 1990 to improve health and safety in the construction industry. The office works with construction industry management and labor to implement proactive strategies for worker protection that make safety and health part of workplace culture.

## Major Activities Contributing to the Construction and Building Program

- Set standards to reflect construction industry safety performance and the need for worker protection.
- Conduct worksite inspections to enforce standards.
- Provide training to construction safety and health enforcement personnel to improve inspections. Training is also provided to industry personnel through agreements with local educational institutions, including community colleges.
- Investigate accidents to determine industry wide causative factors to be reduced or eliminated.
- Establish cooperative programs with companies to benchmark good safety practices and recognize those contractors who are role models for the industry.
- Coordinate federal activity to assure a government leadership role in promoting health and safety programs through responsible construction project ownership.

## Contact:

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# U.S. Environmental Protection Agency
# Washington, D.C. 20460

## Mission:

The mission of the U.S. Environmental Protection Agency (EPA) is to preserve and improve the quality of the environment, protect human health, and safeguard the productivity of natural resources on which all human activity depends. To achieve these goals, the Agency is committed to reduced risks to humans, the environmental, and natural resources using the best available science and innovative technologies.

While all aspects of EPA's activities can be linked to construction and building (C&B), major activities contributing to C&B goals include:

## Major Activities Contributing to the Construction and Building Program

- Provide leadership in the identification, characterization, and mitigation of indoor air pollutants. Develop technologies for the prevention of indoor air pollution.
- Promote energy conservation, efficient energy use through voluntary actions such as the energy star buildings, green lights and energy star computer programs.
- Promote sustainable development through the Green Buildings Initiative, the Environmental Technology Initiative, and Community based, in place environmental management.
- Promote the safe and sustainable reuse of idled and underused industrial and commercial facilities through the Agency's "Brownfields Initiative".
- Promote efficiency and streamline environmental regulation through the Agency's Common Sense Initiative.
- Provide leadership in the nation's environmental science, research, training and assessment.

## Contact:

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# Department of Transportation (DOT)

## Mission:

The primary mission of the Department of Transportation (DOT) is to ensure safety, mobility, and efficiency in the movement of people and goods within the U.S. transportation system, while preserving the environment, advancing technology, and promoting economic growth. DOT encompasses 10 modal administrations with safety and regulatory jurisdiction over highway planning, development, and construction; highway traffic safety; urban mass transit; railroads; national air space operations, airport planning and aviation safety and security; the safety of waterways, port and commercial shipping and the safety of oil and gas pipelines as well as hazardous materials transportation.

Traditionally, operating and research support programs have been carried out primarily by transportation mode (e.g., air, marine, rail) within the operating administrations. However, since the enactment of the Clean Air Act Amendments of 1990 and the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, R&D activities increasingly have been integrated and coordinated across transportation modes.

Overall, the DOT invests over $700 million per year in R&D of which over $300 million per year goes into physical infrastructure related R&D. This comes from the DOT Budget Outlays for Transportation of about $40 billion per year. These Federal disbursements are augmented by greater combined expenditures at the various levels of Non-Federal government (state, county, city, local).

## R&D and the Pratical Goals

The DOT physical infrastructure R&D is primarily related to the National Construction Goals on:

1. Reduced delivery time.
2. Reduced operating maintenance and energy costs.
3. (Productivity goal not directly applicable).
4. (Occupant goal not directly applicable).
5. Less waste and pollution.
6. More durability and flexibility.
7. reduced construction work illnesses and injuries.

Under 1.) The primary impetus is to "fast-track" more physical infrastructure-related construction. This includes R&D on materials and construction procedures which technically speed up contruction, but also related to contracting procedures (design-build), incentives (bonuses/penalties), and quality (warranties/guarantees).

Under 2.) The incentive is to reduce the costs of operating and maintaining the transportation infrastructure. About half of the $100 billion spent per year (total of all government level expenditures for transportation) goes for maintenance and as the system ages, the maintenance costs continue to increase.

Under 5.) The incentive is to make the transportation system more environmentally attractive and to promote "system sustainability." R&D continues to reduce pollution (eliminate lead paints), recycle its components (asphalt pavement recycling), and incorporate other wastes from society (slags, fly ash, etc.).

Under 6.) Research is being performed to develop transportation facilities which can serve the public longer without unduly increasing the first cost. More facilities are built with consideration to the life-cycle aspects. High-performance materials are being developed to provide less massive, longer lasting facilities which can be more easily expanded as future needs change (such as adding lanes to highways).

Under 7.) Everyone is aware of the direct and indirect costs and hardships that result from worker injury. Heavy construction continues to have a relatively high accident rate and bridge building, lock and dam construction, and highway widening all have their share of risk. The most publicized programs to improve safety in recent years have been those associated with highway workers where considerable improvements in safety features are evident to the traveling public (barrier walls, mobile crash barrier on shadow vehicles, etc.). Additionally, there is considerable R&D related to reducing the hazards to users of the transportation infrastructure, such as from wind, floods, earthquakes, eruptions, fires, sinkholes, terrorism, and other accidents.

## Collaboration Needed:

DOT welcomes other public agencies, societies, academic, and industry to join in "improving the state of the practice of civil infrastructure technologies through the use of R&D and deployment." DOT can not bring about change by itself. The U.S. government participates in about 30% of the nation's construction and if change is to occur, we need to get others involved to bring about consensus. This was recently demonstrated when the steel reinforcing bar industry rejected the governments proposed standards for hard metric conversion. The industry's response was that a change would require a dual inventory which would be costly to industry.

## Major Areas Where Others Can Contribute to the Construction and Building Program:

- Research on high- performance materials for renewal engineering will provide stronger, longer-lasting structures and facilities.
- Research on Sensors, Diagnostics and Analysis will develop nondestructive testing and monitoring technology for futuristic transportation systems.
- Research on Automation for Renewal Engineering will supply robotics and site integration technologies that will reduce manpower requirements.
- Research on Reduction of Intermodal Hazards will help provide emergency response to transportation interruptions caused by earthquakes, floods, wind storms, etc., and restore lifelines.
- Research related to bridges, pavements, and geotechnology will provide more cost-effective facilities.
- Development of contracting procedures, life-cycle analysis methodology, incentive systems, innovative financing methods, and quality control technology will encourage innovation.
- Research on recycling, fast-track construction, and the use of local wastes, other reclaimed, or marginal materials will conserve resources.
- Research on in situ enhancement of decaying structures will allow more cost-effective restoration.

## Specific mechanisms for collaboration:

DOT has a goal in its strategic plan that states the following:

"Goal 3: Create a new alliance between the nation's transportation and technology industries to make them both more efficient and internationally competitive."

"Goal 3.3 Support the use of advanced materials in manufacturing and constructing transportation equipment and facilities."

DOT has in the past done research that enhanced its role as a regulator of transportation. Hence, its new role as partner with industries is still evolving, particularly with respect to changing the procurement activities to encourage CRADA's and other partnering arrangements.

Each of the agencies of DOT has established procedures for conducting its research programs. There are internal and external programs. Amount the internal mechanisms are those related to direct procurement and among the external are the activities funded by Federal Aid or grants to states, NCHRP, NCTRP, institutes, university centers, LTAP, RTAP, etc. DOT's agencies also do cooperative funding through or with other agencies on projects of mutual interest, such as with NIST, Corps. of Engineers, ARPA, NSF, DOE, USDA, FEMA, etc.

Only a few of the programs are presented here:

- Direct contract solicitations. The agencies solicit in the CBD for proposals to problem statements.
- SBIR. DOT solicits each year with proposals due on May 1 to address specific research topics.
- Unsolicited Proposals. Each agency has a procedure for handling unsolicited proposals. In the past few proposals were funded.
- State Planning and Research Programs. this is a FHWA program in which the states have approximately $80 million collectively to fund highway research. The initiative is with the states, so inquires should be sent to the particular state.

Additional details are available from DOT's Research and Special Programs Administration report Materials Research and Technology Initiatives (DOT T 96-01), November, 1995.

Another source of information (which may soon be out of date) is draft report FHWA-RD-95-015 of Spring, 1995 "Program Fact Sheets: Transportation Research and Technology."

**Resources Available:**

DOT agencies have various facilities that are available for possible use in CRADA's :

## MAJOR DOT RESEARCH CENTERS AND LABORATORIES

John A. Volpe National Transportation Systems Center (RSPA)
Cambridge, MA

Turner-Fairbanks Highway Research Center (FHWA)
McLean, VA

FRA/AAR Transportation Test Center and Hazardous Material Training Center
Pueblo, Co

FAA Technical Center
Atlantic City, NJ

Mike Moroney Aeronautical Center (FAA)
Oklahoma City, OK

U.S. Coast Guard Research and Test Center (VRTC)
Groton, CT

NTSA Vehicle Research and Test Center (VRTC)
Liberty, OH

FTA Bus Testing Facility, Pennsylvania Transportation Institute
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# DOT CONTACTS:

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# Department of Veterans Affairs
# Office of Construction Management
# Washington, D.C. 20420

## Mission:

VA is dedicated to constructing quality facilities for serving veterans in medical centers, outpatient clinics, nursing homes, domicliaries, regional office buildings, and cemeteries. VA's Office of Construction Management implements planning, design, construction, and real estate programs in support of the department's missions, with a strong commitment to customer service. CM also promotes maximizing VA-owned assets through creative development initiatives.

## Major Activities Contributing to the Construction and Building Program

- Updating, consolidating, and automating Design and Construction Standards
- Developing criteria for operating in and responding to natural disasters
- Creating Design Guides to improve quality, control cost, and increase user satisfaction
- Managing traditional and alternate methods of design and construction, emphasizing the use of Design Programs to minimize the need for change
- Reviewing project designs for function, efficiency, and flexibility
- Creating and maintaining a Cost Data Base for budgeting

## Contact:

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# General Services Administration
# Public Building Service
# Washington, D.C. 20405

## Mission:

The General Services Administration (GSA) is the Federal business manager which responsibilities including space acquisition and management, retail and wholesale supply sales, fleet management, travel and transportation management, telecommunications and information management.

The Public Buildings Service (PBS) serves as the Federal Government's chief buildings planner, developer, owner, and real property asset manager. PBS managers over 8,000 buildings providing in excess of 24.8 x $10^6 m^3$ million square feet.

## Major Activities Contributing to the Construction and Building Program

• The design and construction program in progress is estimated to be $8 billion, and more than $2 billion has been budgeted annually for new projects.

• Since 1973 energy consumption in PBS buildings has been reduced by more than 40 percent and eight percent from 1985 levels. Current energy usage is more than 40 percent below the Federal average.

• GSA participates with local utility companies' demand side management rebate programs. GSA now participates in energy rebate programs, retains the savings, and reuses the funding resources for additional program requirements.

• The PBS' Design Excellence Program has invigorated the design community to actively pursue GSA projects. GSA's new program stresses creativity, including the exploration of innovative use of technology. Emphasis is placed on the unique aspects of the particular project, design philosophy, possible approaches in carrying out the project, and project management.

The Health Care Financing Administration Headquarters located near Baltimore, MD, is scheduled for occupancy in late 1995. The facility is being developed by Boston Properties, Inc., with the GSA's Public Buildings Service serving as project management agency. The facility provides for innovative wetland conservation methods and energy management.

## Contact:

Wade Belcher, Public Building Service, GSA
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# National Science Foundation

## Mission:

The National Science Foundation (NSF) is created to promote and advance scientific and engineering progress in the United States. NSF funds research and education in most fields of science and engineering, through grants, contracts and cooperative agreements to colleges, universities, small businesses, and other institutions. Civil infrastructure systems (CIS) research (which includes the Construction and Building Program) is one of the Foundation-wide initiatives.

## Major Activities Contributing to the Construction and Building Program

**DETERIORATION SCIENCE** examines how materials and structures break down and wear out, improving our understanding of deterioration and design, and how to build, and maintain structures that are more durable, safer, and more environmentally sound.

**ASSESSMENT TECHNOLOGIES** determines durability, safety, and environmental conditions of structures and facilities. Research can lead to nondestructive evaluation techniques, improved sensor technologies, and self-correcting materials.

**RENEWAL ENGINEERING** extends and enhances the life of civil infrastructure systems and components that would otherwise continue to deteriorate.

## Opportunities for Collaboration with the Private Sector

The following NSF programs provide opportunities for collaboration with the private sector in terms of R&D, sharing facilities, joint research with universities, technology/knowledge transfer and other activities.

Engineering Research Center (ERCs) - Focused major cross-disciplinary programs of research and education on engineering systems important for competitiveness. The ERCs have been established to work in close collaboration with industry to improve industrial input into research and education programs and to speed the transfer of knowledge into engineering systems important for industry. The ERCs have major educational programs designed to improve the contribution of engineers to competitiveness, emphasizing experience with research organized to promote cross-disciplinary teamwork and experimentation with engineering testbeds. ERCs are located at academic institutions where they are expected to promote strong links between research and education. An example of the CIS related ERC is the Center for Advanced Technology for Large Structural Systems at Lehigh University. Similar to the ERCs, the NSF Science and Technology Centers (STCs) such as the Center for Advanced Cement-based Materials at Northwestern University also has modern state-of-the-art facilities and industrial participation.

Industry/University Cooperation Research Centers (I/UCRCs) - Encourage highly leveraged industry/university cooperation by focusing on fundamental research recommended by Industrial Advisory Boards. Each center is established to conduct research that is of interest to both industry and the University, with a provision that industry take over full support of the center within five years.

The successful I/UCRC Program model has been extended to encompass a new type of center, the State/Industry University Cooperative Research Centers (S/IUCRCs). These centers are focused more actively on State or regional local economic development and are initiated at the State level with industrial support. They compete for NSF support in an announced competition. This new model extends the I/UCRC model to focus on more active means of technology transfer, which can include experimentation with testbeds, hands-on teaching of new concepts to upgrade small business, etc. These centers also may extend their work to include proprietary projects designed to speed development with the support of industry and the State.

Examples of CIS related I/UCRCs are: The Center for Building Performance and Diagnostics (CBPD) at Carnegie Mellon University, and the Center for Nondestructive Evaluation (CNDE) at Iowa State University.

Small Business Innovation Research (SBIR) - Offers opportunity and incentive for small and creative engineering, science, education, and technology related firms to conduct innovative, high risk research on important scientific and technical problems-work that could have significant public benefit if the research is successful. This is a three-phase program that offers incentives for converting research done in Phases I and II to commercial application in Phase III, with the final effort funded by private capital.

Industry/University Liaison Program - Comprises the Small Business Technology Transfer (STTR) Program and the Grant Opportunities for Academic Liaison with Industry (GOALI) Initiative. STTR is a federal program that links entrepreneurs to the academic research community. It encourages commercialization of Government -funded research by the private sector, reinforcing the efforts of the SBIR Program. STTR proposals must have small business principal investigators, but up to 60 percent of STTR funding may support university subcontracts to assist in the commercialization of research products by the small business firm. GOALI provides opportunities through a series of mechanisms for direct linkage between academic researchers and industry.

Management of Technological Innovation (MOTI) - Supports research in the management of engineering and technology to create knowledge, methods, and tools to improve the ability of engineering design and manufacturing practice in order to better determine and meet market needs, and improve corporate ability to integrate technology strategy with business strategy. The program focuses on the interface between engineering and business and supports interdisciplinary research initiatives.

**Contact:**

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# Appendix D: Additional Collaborative Success Stories

(NOTE: Most of these success stories are photo copied from already printed documents. Conversion to SI units has not been made).

## Collaboration Success Stories

### SAFETY

#### Clean-up



#### Falls



#### Fire Safety



#### Highways



#### Windows

INFORMATION SYSTEMS



HIGH PERFORMANCE MATERIALS

US Army Corps of Engineers

**Construction Productivity Advancement Research (CPAR)**

# Fact Sheet

Directorate of Research and Development
Attn: CERD-C
20 Massachusetts Avenue, N.W.
Washington D.C. 20314-1000
(P) 202-761-0257

A Corps/Industry Partnership to Advance Construction Productivity and Reduce Costs

CP-2
Jul 95

## Asbestos Abatement/Destruction Using Plasma Arc Technology

***Technology Challenge***

Approximately 192,000 public buildings in the U.S. contain an estimated 1.2 billion square feet of sprayed-on or trawled-on asbestos-containing materials (ACMs). The U.S. Department of Defense is currently facing multi-million dollar rehabilitation costs relating to asbestos removal and disposal from these buildings.

At the present time, ACM removal and disposal projects are generating a considerable amount of hazardous waste material. Under the 1986 Asbestos Emergency Response Act, ACMs can only be deposited at selected Class 1 Environmental Protection Agency (EPA)-approved landfill disposal sites which comply with the National Emissions Standards for Hazardous Air Pollutants. Higher disposal costs are anticipated as these EPA-approved disposal sites reach their full capacity. In addition, the U.S. Army Center for Public Works has recommended that installations manage asbestos in place.

***Description of the Product***

Plasma heating was originally developed for the metallurgy industry as an efficient alternative to conventional heating. A plasma torch is a tubular device that converts electricity into heat via the resistance of a plasma. Plasma is the state of matter where gases are ionized. At this stage they are highly conductive and generate considerable heat.

The very high temperatures (3,000-7,000°C) achievable with plasma arc torches make this technology a viable and powerful tool for the thermal destruction of ACMs, When pure asbestos is subjected to temperatures above 1000°C, the asbestos fibers melt and subsequently solidify into a non-hazardous, chemically inert, solid material. The resulting slag-like substance meets all EPA criteria for transportation and disposal into regular landfills.

***Status of Project***

The EPA has recognized the Plasma Arc concept of thermal destruction of asbestos as a viable technique in rendering asbestos harmless. As landfill disposal costs increase, this technology is expected to become an increasingly attractive and competitive alternative

throughout the U.S.

The currently on-going Phase II of the CPAR project aims to develop basic design criteria for a prototype mobile 15-ton-per-day Plasma Asbestos Pyrolysis System (PAPS). PAPS would be a truck-mounted furnace for the on-site, safe, and final disposal of asbestos fibers and ACMs. Any form of asbestos wastes could be fed into PAPS and converted into a molten slag liquid. Asbestos solidification operating costs for a 7 ton per day mobile PAPS are estimated at $163 per ton. These commercially competitive costs are about equal to the median level of 1988 ACM landfill disposal costs in the U.S.

USACERL is continuing Phase II CPAR project with Georgia Tech. The objective is to conduct all the research necessary to test and evaluate the innovative concepts required for the vitrification and destruction of asbestos-containing materials (ACM), taken directly from ACM-polluted construction materials from the Atlanta metropolitan area. These materials are being processed and tested using the experimental furnace and research facilities located within the Georgia Tech Research Institute. This work gives the construction industry and the Army an opportunity to become acquainted with the applicability and potential of Plasma Arc technology for future asbestos abatement/destruction projects. This technology has the potential to be applied in municipal and hazardous waste disposal sites as a high-intensity heat source for the gasification, vitrification, and environmentally safe destruction of waste materials.

***Partnering***

| | |
|---|---|
| Laboratory: | U.S. Army Construction Engineering Research Laboratories (USACERL), Champaign, IL |
| Industry Partner: | Construction Research Center (CRC), Georgia Institute of Technology, Atlanta, GA |

***Cost Sharing***

The total cost of the project is $720K. The industry partner share is $395K, and the laboratory share is $325K.

***Points of Contact***

CRC POC is Dr. Louie J. Circeo, COMM 404-894-2070; FAX 404-894-7989; or CRC, Georgia Institute of Technology, Atlanta, GA 30332-0159.

USACERL POC is Dr. Ed Smith, COMM 217-373-3488; toll-free 800-USA-CERL; FAX 217-373-3490; or USACERL, ATTN: CECER-UL-I, P.O. Box 9005, Champaign, IL 61826.

US Army Corps of Engineers

Construction Productivity Advancement Research (CPAR)

# Fact Sheet

Directorate of Research and Development
Attn: CERD-C
20 Massachusetts Avenue, N.W.
Washington D.C. 20314-1000
(P) 202-761-0257

A Corps/Industry Partnership to Advance Construction Productivity and Reduce Costs

CP-17
Jul 95

## Vitrification and Removal of Lead-Based Paint

***Technology Challenge***

A method of deleading steel structures is needed to help curb the environmental hazardous associated with lead-based paint. By flame spraying molten alkali silicate glass on highway bridges (state and federal) and service bridges for civil works hydraulic structures, the need for specialized structure containment for hazardous lead oxide dust and sand will be eliminated. Such a method would also allow the lead containing waste to be nonhazardous.

***Description of the Product***

This effort will determine a method for removing lead-based paint using thermal spray technology, and the correct glass composition for effective and safe removal. The process uses molten alkali silicate glass and to vitrifies the lead-based paint on steel surfaces, immobilizing the hazardous heavy metal lead ions.

***Status of Project***

The glass powder size distribution for optimum thermal spray was determined to be -150, +230 mesh. The initial number of passes required to remove lead completely from steel coupons coated with the lead-based paint primer was four. Analysis of the glass fragments from the flame spraying was conducted to determine the amount of lead contained within the fragments as well as the waste classification level of those glass fragments. Iron oxide glass was used to reduce the leaching of lead from the glass slag. The thermal spray process is being optimized at USACERL and SUNY laboratories, and arrangements are being made with the Triborough Bridge Authority, NY, for the field demonstration in July 1995.

***Partnering***

| | |
|---|---|
| Laboratory: | U.S. Army Construction Engineering Research Laboratories (USACERL), Champaign, IL |
| Industry Partner: | State University of New York at Stony Brook (SUNY), NY |
| Participants: | Triborough Bridge Authority, New York |
| | Eutectic-Castolin Corporation, Flushing, New York |
| | APS Materials, Inc., Dayton, Ohio |
| | GPA Inc., Windsor Locks, Connecticut |

***Cost Sharing***

The total cost of the project is $1,000,000. The industry partner share is $600K and the laboratory share is $400K.

***Point of Contact***

SUNY POC is Dr. H. Herman, State University of New York (SUNY), Stony Brook, NY, 11794-2275.

USACERL POC is Dr. A. Kumar, COMM 217-352-6511 ext. 7235; toll-free 800-USA-CERL; or USACERL, ATTN: CECER-FL-M, P.O. Box 9005, Champaign, IL 61826-9005.

# Fact Sheet

## BIOREMEDIATION OF HYDROCARBON-CONTAMINATED SOIL IN NORTHERN CLIMATES*/**

### PROBLEM

Extreme climatic conditions create unique problems for conventional technologies. Short operating seasons combined with low-temperature-unique chemical, physical and biological phenomena challenge existing methods.

### SOLUTION

To develop cost-effective solutions for bioremediation techniques in northern climates, we are exploring three approaches:

- Enhanced landfarming
- Recirculating leach bed
- Infiltration gallery trickling filter with groundwater recycling

All three technologies are being demonstrated at the same field site. Modifications to mechanical systems were designed to solve difficulties associated with extremely low temperatures and to allow system shutdown during the winter. These engineering solutions are integrated with an intensive scientific monitoring effort focused on field measurements of microbial kinetics. The natural variability in the field biodegradation rates is being exploited to estimate the potential for identifying and removing limitations to bioremediation. We have demonstrated the benefits of low-cost, readily implemented biotreatment applicable to cold regions and the problems related to in-situ treatment systems. Extensive field monitoring has clearly shown the inherent difficulty caused by spatial variability in obtaining readily interpreted field data. We are applying geostatistical techniques to address this limitation.

This project is a Corps of Engineers Construction Productivity Advancement Research (CPAR) project, which is a cost-shared, cooperative research program designed to enhance the competitiveness of the United States construction industry. The U.S. Army Cold Regions Research and Engineering Laboratory (USACRREL) is partnering with the Alaska Department of Transportation and Public Facilities (AKDOT & PF).

### RESULTS

Degradation rates within the landfarm varied sevenfold. This variance may be attributed to changes in soil nutrients and moisture potential. Results have suggested that treatment in one season is feasible. The approximate cost for this technology has been $20 to $40 per cubic yard. Use of the recirculating leach bed was deferred due to a break in the liner, but a similar system remediated highly contaminated soil at a remote site for approximately $150 per cubic yard. The petroleum hydrocarbon concentrations in the infiltration gallery sampling wells have decreased to acceptable levels.

### CONTACTS

Dr. Mike Reynolds
603-646-4394
reynolds@crrel.usace.army.mil

W. Alan Braley, P.E., Airport Engineer, Alaska Department of Transportation and Public Facilities, Fairbanks International Airport, Fairbanks, AK 99706

* *This fact sheet supersedes December 1994 version of the same title.*

** *There is a CPAR version of this fact sheet, also dated April 1995.*

April 1995

US Army Corps of Engineers
Cold Regions Research & Engineering Laboratory

CRREL, 72 Lyme Road, Hanover, NH 03755-1290

Occupational Safety and Health Administration

# SUCCESS STORY

## THE NEW OSHA - GETTING RESULTS, IMPROVING PERFORMANCE

### FALLS DURING STRUCTURAL STEEL ERECTION
### ATLANTA EAST AREA OFFICE STRATEGIC INITIATIVE

**Problem:** Construction contractors are facing rising workers compensation costs for fatalities and injuries from falls and other construction accidents. OSHA's mission is to prevent accidents and injuries, but the agency primarily relied on enforcement inspections that reached a limited number of sites, often after the accident had occurred. The agency needed more proactive interventions.

**OSHA's New Strategy:** The Atlanta East Area Office is one of two prototype offices that piloted OSHA's new way of working. The New OSHA area offices now focus on "Getting Results and Improving Performance" - GRIP. By teaming with Argonaut Insurance Company, Atlanta OSHA helped a steel erection contractor, Horizon Steel, establish a comprehensive safety and health program that had management commitment, line accountability and full employee participation. OSHA provided onsite hazard assessment and Argonaut trained all Horizon supervisors in accident reduction techniques. Argonaut also assisted Horizon in implementing a supervisor accountability program that focused on goals, performance measures and pay, tying bonuses to safety. Horizon also instituted a 100% fall protection program for all workers above six feet.

**Results:** Horizon reduced its insurance costs by 96% and maximum claim costs were reduced 98 %. Since instituting 100% fall protection, six iron workers have survived falls over 50 feet. At the conclusion of this project, the company's president implemented a program that requires the use of union employees at all worksites.

| Results | Before | After |
|---|---|---|
| Accident costs per man hour | $4.26/hour | $0.18/hour |
| Total claim costs | $1,063,954 | $13,200 |

Contact: Office of Reinvention Room N3603
U.S. Department of Labor - OSHA
200 Constitution Avenue NW
Washington, DC 20210
202-219-7725

Occupational Safety and Health Administration

# SUCCESS STORY

## THE NEW OSHA - GETTING RESULTS, IMPROVING PERFORMANCE

**FALLS FROM ROOFS**
ST. LOUIS AREA OFFICE STRATEGIC INITIATIVE

**Problem:** Sixty-one employees had been injured in falls from roofs in the first six months of 1995 according to the Greater St. Louis Roofing and Siding Contractor Association and the Roofing Contractors of Greater St. Louis. Ten negative articles appeared in local newspapers directed at residential style roofing operations. Labor Department statistics confirmed that nearly half of all construction fatalities result from falls; sixty percent of them from roofs. Contractors were confused about OSHA's new Fall Protection Standard and needed hazard assessment training to help address the growing problem of falls from residential style roofs.

**OSHA's New Strategy:** Team St. Louis (OSHA area office) formed partnerships with local roofing contractors, roofers' unions, and fall protection suppliers to provide training and technical support. The Partnership promotes using hazard assessment as a critical element of the alternative fall protection plans contained in the standard. A local roofing committee, representing all partner groups (including employee groups), is the intermediary between the residential style roofing industry and OSHA. Team St. Louis conducted four hazard assessment training sessions for approximately 280 contractors, employee representatives and others. They helped the roofing association produce a video demonstrating the common sense approach to OSHA's fall protection standard.

Results: In six months, injuries resulting from falls from roofs, as reported by the two contractor associations, has declined 70 percent. A trade magazine article lauded the OSHA/roofing industry/employee partnership. A participating contractor told a congressional committee wanting to hear negative stories about OSHA that he now sees the New OSHA in a different light.

| Results | Before (Jan 95-Jun 95) | After (Jul 95-Dec 95) |
|---|---|---|
| Injuries from falls | 61 | 18 |

Contact: Office of Reinvention Room N3603
U.S. Department of Labor - OSHA
200 Constitution Avenue NW
Washington, DC 20210
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NIST

BUILDING AND FIRE RESEARCH LABORATORY

# Success Story

## Alarm and the Fire Safety Evaluation System

NIST researchers developed software to help fire safety officers and building managers at health care facilities achieve cost-effective compliance with fire codes. The software is called ALARM, which stands for *A*lternative *L*ife Safety *A*nalysis for *R*etrofit Cost *M*inimization, and was developed in cooperation with the U.S. Public Health Service (USPHS) and the National Fire Protection Association (NFPA). The software generates a set of alternative compliance strategies, and their estimated costs, for meeting the NFPA *Life Safety Code (LSC)*. The LSC is a widely used, voluntary code for identifying the minimum level of fire safety in buildings. Compliance with the LSC is a condition for accreditation by the Joint Commission on Accreditation of Health Care Organizations.

The primary code of the LSC is prescriptive, since it requires specific solutions for fire safety. For example, it might require a minimum fire retardancy rating for interior finishes and the presence of manual fire alarms. However, a provision allows for alternative code compliance through a goal-oriented, or performance-based, fire safety code. Through use of an equivalency concept, performance-based codes determine how combinations of fire safety parameters can achieve a level of fire safety equivalent to that required by prescriptive codes.

Health care is the first building occupancy to be covered by an equivalency system. The system was originally developed in the late 1970's at NIST (then the National Bureau of Standards). The NFPA subsequently adopted this equivalency system into the Life Safety Code in 1981. This performance-based code, known as the Fire Safety Evaluation System (FSES), has been modified and updated several times since then. The current (1995) version is published as NFPA 101A and also includes other occupancies such as business, board and care, and correctional facilities. *ALARM* currently supports the FSES for health care occupancies.

Since 1981, the approach used in *ALARM* has been field tested by the USPHS in a large number of military, public, and private hospitals. The cost savings have been substantial; *ALARM's* economical, performance-based solutions are typically saving hospitals between 30 and 35 percent of the cost of implementing prescriptive codes. In 1993, the software was applied to the largest hospital yet, the 60-zone, 62,710 square meter (675,000 square foot) Wright-Patterson Air Force Base hospital in Ohio. *ALARM* estimated that the cost savings from using the alternative FSES solution was over $500,000. The results of the surveys on 86 military hospital facilities

representing about 16,000 beds show estimated cost savings of over $35 million, an average savings of $2,200 per bed.

With the success of the FSES for health care occupancies, performance-based codes have been developed for other occupancies such as business occupancies, board and care facilities, and detention and correctional facilities. The *ALARM* methodology for reducing code compliance costs is equally applicable to these and even other occupancies as more FSES systems are developed. Software tools tailored to these occupancies could be developed in the future.

Contact:

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Occupational Safety and Health Administration

# SUCCESS STORY

**THE NEW OSHA - GETTING RESULTS, IMPROVING PERFORMANCE**

## HIGHWAY CONSTRUCTION SAFETY
PARSIPPANY AREA OFFICE STRATEGIC INITIATIVE

**Problem:** Bureau of Labor Statistics data, workers' compensation and insurance data and state fatality data identified numerous fatalities and injuries to highway workers in the State of New Jersey. The State Police of New Jersey requested assistance from OSHA's Parsippany Area Office to combat a rising death toll.

**OSHA's New Strategy:** The Parsippany Area Office formed a partnership with the N.J. Department of Transportation, the N.J. State Police, and the Laborers International and Local 472. The State DOT developed contract language requiring safety and health programs and specific engineering controls and is providing onsite assistance via DOT project engineers. The N.J. Police Construction Safety Squad has the role of onsite monitor and is a source for inspection referrals and project impact measures. The international and local unions are developing training programs for employees, employers, and the State Police. The goal of the project is to reduce injuries and death to highway construction workers. Interim impact measures include: State Police Construction Safety Squad intervention reports; training comprehension; establishment of safety and health programs; and compliance data resulting from referral inspections.

**Results:** State troopers reported making four times as many safety and health interventions. The hazards included unsafe lane closure, inadequate crew protection, unsafe site vehicle operation and hazards to the public.

| Results | Before | After |
|---|---|---|
| State Trooper interventions | 93 | 374 (+300%) |

Contact: Office of Reinvention Room N3603
U.S. Department of Labor - OSHA
200 Constitution Avenue NW
Washington, DC 20210
202-219-7725

# ENGINEERING CONTROLS FOR ASPHALT PAVING EQUIPMENT

**A Partnership between Federal Government and the Asphalt Paving Industry**

The asphalt paving engineering controls project is a shining example of the obtainable success when government and industry join together for a common cause. Key players involved in this project include; The National Asphalt Pavement Association (NAPA), The National Institute for Occupational Safety and Health (NIOSH), Five Asphalt Paver Manufacturers, Asphalt Paving Contractors, The Federal Highway Administration (FHWA), Organized Labor, and several State-level Departments of Transportation. A list identifying the role of each contributor is attached.

The asphalt paving engineering controls project originated in 1993 and was the brainchild of NAPA and its members. The science concerning the health effects of paving-related exposures to asphalt fume was inconclusive. Thus, the study originated as a proactive attempt to improve the working environment for asphalt paving workers and reduce their exposures to potentially harmful contaminants. NAPA members viewed the project as a win-win situation for both asphalt workers and contractors. An Engineering Controls Task Force was created to began development and evaluation of control designs on paving equipment from three manufacturers.

Initial field trials indicated that local exhaust ventilation techniques held promising potential to reduce worker exposures. However, the Task Force recognized the need for outside assistance in optimizing the engineering controls' performance capabilities and in conducting a thorough performance evaluation of the final prototype designs. NAPA approached FHWA with a project proposal and a request for funding under the Applied Research and Technology Program of the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA). The NAPA proposal requested NIOSH to individually assist each participating manufacturer with the design optimization of their prototype engineering controls. Additionally, NIOSH would evaluate each engineering control's ability to capture generated contaminants during the asphalt paving process. By this time, the number of participating paver manufacturers had increased to five and represented over 80% of highway-class paver sales.

NIOSH engineers developed a two phase protocol to evaluate and to assist in the development of engineering controls for asphalt paving equipment. Phase I used stationary evaluations to test the controls' ability to capture surrogate contaminants from within each paver's auger area. Phase I evaluations were conducted at each participant's manufacturing plant and consisted of indoor and outdoor stationary evaluations. During this phase, theatrical smoke provided qualitative performance evaluations while tracer gas techniques were employed to quantify exhaust volumes and capture efficiencies for each prototype design.

The laboratory evaluations of engineering controls for asphalt paving equipment proved extremely useful in refining the prototype designs. Several manufacturers discovered they had insufficient exhaust capacity to capture and remove the contaminant. One manufacturer used the laboratory evaluation results to select the best performing hood from among three prospective designs.

Another manufacturer discovered that engine cooling air was blowing into the auger region and disrupting the control's capture velocity. All the manufacturers identified areas where their designs were susceptible to cross-draft interferences. Armed with this performance data, participating manufacturers have refined their prototype designs in preparation for phase II performance evaluations to begin this spring during actual paving operations.

## PARTICIPATING GROUPS AND THEIR RESPONSIBILITIES

**FEDERAL HIGHWAY ADMINISTRATION (FHWA)**: Work with states to locate federal aid projects where participating manufacturers' prototype pavers can be used by paving contractors for evaluation purposes. Coordinate funding and administrative details with NIOSH to perform the testing and evaluation process. Develop a final report on activities and findings in conjunction with NOSH.

**STATE DEPARTMENTS OF TRANSPORTATION**: Work with FHWA to locate projects and develop contract documents appropriate to include prototype testing during asphalt paving projects.

**NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)**: Assist manufacturers in the design and optimization of prototype engineering controls for asphalt paving equipment. Evaluate prototype engineering control equipment and document effectiveness of control equipment to reduce worker exposures. Develop a final report on activities and findings in conjunction with FHWA.

**ORGANIZED LABOR**: Assist and provide guidance on work plan and testing protocol. Assist in the information dissemination to employees working at identified paving sites.

**PAVER MANUFACTURERS**: Develop and build engineering control modification packages and install prototype design on participating contractor's paving equipment at test sites selected by the States and FHWA.

**NATIONAL ASPHALT PAVEMENT ASSOCIATION (NAPA)**: NAPA and their affiliate, The Asphalt Institute (AI), provide technical guidance and assistance to facilitate the development of testing protocols designed to evaluate control equipment and worker exposures. Provide coordination support between NIOSH, FHWA, participating paver manufacturers, and contractors.

NATIONAL SCIENCE FOUNDATION
4201 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22230

**Agency**: NSF

| | |
|---|---|
| **Program Title**: | Structural Systems and Construction Processes/ Energy Dissipation of Tubular Structural Systems |
| **Products**: | Through rigorous analytical and experimental research, proof of concept , design criteria and innovative hardware for the energy absorption and dissipation of tubular (barrel) systems impacted by the direct crashing of vehicles. |
| **Goal Impacted**: | Improved life-saving of highway impact attenuation devices. |
| **Quantification of Impact**: | NSF grantee John Carney (Vanderbilt U.) conducted pioneering research in energy dissipation and large deformation of tubular (barrel) structural systems, later on developed into highway impact attenuation (later developed by Connecticut DOT). These devices, to be crashed by cars, are usually located at the exit of interstate highways, saving thousands of lives and about $400 million annually in societal savings. |

Point of Contact: Dr. Ken P. Chong, NSF, (703)306-1361

U.S. CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, D.C. 20207

CPSC SUCCESS STORY

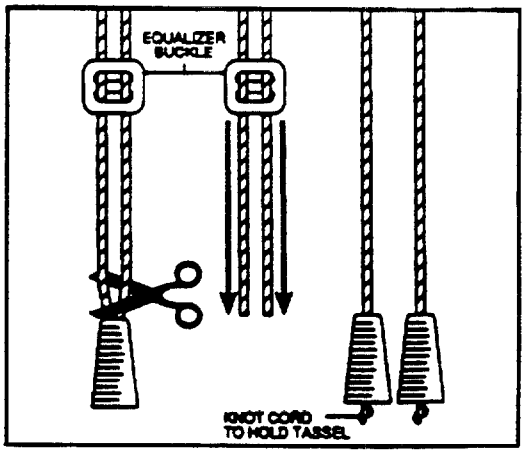
**CPSC Works With Industry to Save Lives:**
**Window Pull-Cords and Strangulations**

The Consumer Product Safety Commission (CPSC) is working with manufacturers of window blinds and shades to reduce stangulation deaths to young children that occur when they get caught in the loops of window covering pull-cords.

CPSC had been concerned with the hazards of window covering pull cords since the early 1980's. Since 1981, over 170 strangulation cases to children involving window cords have been reported, or about one death per month. In about half of these cases, children between eight months and four years old were found hanging in the loop of the cords. In other cases, children were found with pull cords wrapped around their necks. The younger children who died, usually between 8 and 23 months old, were in cribs that were placed near the window cords. The older children, usually between 2-1/2 and 4 years old, strangled in cords when they climbed on furniture to look out windows.

One of the first initiatives of Chairman Ann Brown was to engage manufacturers in discussions to address this serious hazard. In a joint press conference, CPSC and the Window Covering Safety Council (WCSC) advised parents and other consumers to eliminate the loop in two-corded horizontal blinds in the following manner (see figure):

- cut the cord above the tassel,
- remove the equalizer buckle,
- add a safety tassel at the end of each cord (available free from manufacturers).



**Quick Fix to a Serious Hazard**

Manufacturers took steps to prevent future strangulations by eliminating the loop on two-corded horizontal blinds manufactured after January 1, 1995. For other types of window covering pull cords, such as vertical blinds and drapery cords, the industry recommends that consumers use inexpensive tie-down devices to reduce the strangulation hazard.

At present, CPSC is working with WCSC to develop a voluntary standard for window covering pull cords. Manufacturers are free to use any design approach that will satisfactorily address the hazard. CPSC staff estimates that if loops are eliminated from all new and existing window coverings, about 25 children's lives will be saved over 5 years.

NIST

BUILDING AND FIRE RESEARCH LABORATORY

# Success Story

## NIST BACnet™ Interoperability Testing Consortium

BACnet™[1] is a communication protocol for Building Automation and Control networks developed by NIST and approximately 20 industry partners under the auspices of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). It was approved for publication as an ASHRAE standard in June, 1995 and was approved by ANSI as an American national standard in December 1995.

**What will be the impact of BACnet?**

Today's building control systems are made up of distributed, microprocessor-based controllers that are interconnected using proprietary communication protocols. This results in captive customers who must return to the original system vendor to modify or update their building control system, develop expensive custom gateways, or operate the building with multiple, separate control systems. BACnet solves this problem by providing a standard communications infrastructure.

BACnet will permit building owners to obtain competitive upgrades to building control systems and integrate special controllers that come packaged with HVAC equipment (like chillers) with their existing control system. BACnet will also make it possible to integrate building systems that are now stand alone, e.g., fire detection/suppression systems, HVAC control systems, lighting control systems, and security systems. Integration of these systems can improve life-safety, increase comfort, and reduce operation and maintenance costs.

BACnet will also provide opportunities for new kinds of building system products because they will have access to a great deal of valuable information about the status of the building. Two examples are fault detection and diagnostic systems and elevators that can be safely used during a fire to evacuate high-rise buildings. BACnet will also permit greater interaction between building control systems and electrical utilities such as real-time price negotiation and load management.

There is considerable international interest in BACnet. BACnet has been selected by CEN as a pre-standard for the European Community. Activity is now underway in ISO to consider BACnet for ISO standardization. In its broadest possible application, BACnet could impact every commercial building in the world.

**NIST's Role**

NIST played a key role in developing the technical content of the standard and resolving public review comments. In 1993 NIST formed the BACnet Interoperability Testing consortium to verify the technical soundness of the protocol,

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[1]BACnet is a trademark of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

assist control system manufacturers develop interoperable BACnet products and to develop conformance testing tools and procedures. The consortium now has 18 members as shown in the table.

NIST has been developing testing procedures and tools for measuring conformance to the BACnet standard and working with consortium members to refine the testing process while, at the same time, assisting them to develop BACnet building control products. Fourteen members of the BACnet consortium demonstrated interoperable BACnet building control products at the International Air-Conditioning Heating, and Refrigeration Exposition in February 1996. Approximately 25,000 people from the building control industry around the world attended the exposition.

BACnet Interoperability Testing Consortium Members

| | |
|---|---|
| Alerton Technologies | Redmond, WA |
| Andover Controls | Andover, MA |
| Auto Matrix | Export, PA |
| Cimetrics Technology | Boston, MA |
| Cornell University | Ithaca, NY |
| Delta Controls | Surrey, BC |
| Honeywell, Inc. | Minneapolis, MN |
| Johnson Controls | Milwaukee, WI |
| Landis & Gyr | Buffalo Grove, IL |
| McQuay International | Minneapolis, MN |
| NIST | Gaithersburg, MD |
| Orion Analysis Corporation | Baltimore, MD |
| PolarSoft | Pittsburgh, PA |
| Siebe Environmental Controls | Richmond, VA |
| Staefa Control System | San Diego, CA |
| Teletrol | Manchester, NH |
| The Trane Company | St. Paul, MN |
| United Technologies, Carrier | Farmington, CT |

Contact:

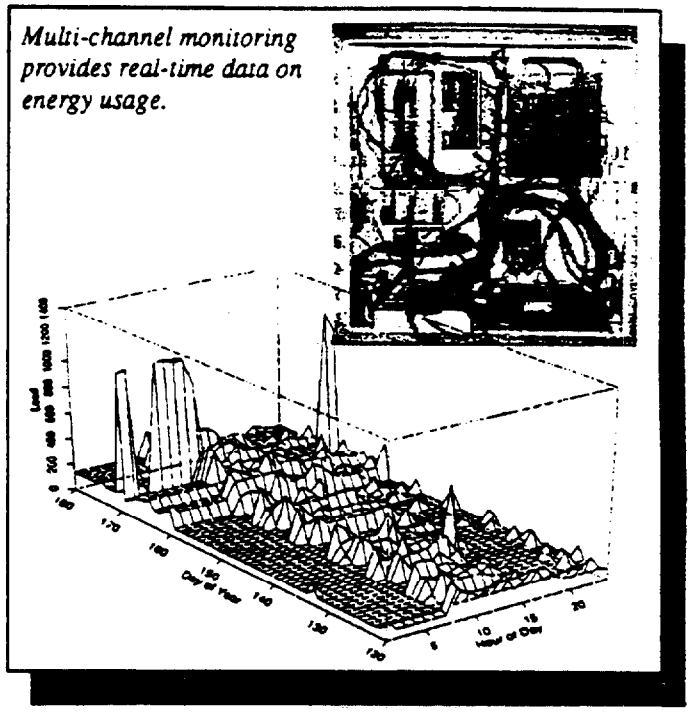
Steven Bushby
B114 Building Research
(301) 975-5873
email: steven.bushby@nist.gov

# Success Story

Office of Energy Efficiency and Rewable Energy

## Data Loggers

In the early 1980's, the Pacific Northwest Laboratory (PNL), the U.S. Department of Energy (DOE), and the Bonneville Power Administration (BPA) initiated a large-scale study to collect detailed information on building energy use. In order to meet the specific research needs of this study, PNL developed a new technology, the Data Logger, which is providing valuable information on how consumers really use electricity. Data Loggers are microprocessor-controlled recorders capable of being used in all types of buildings, from single family residences to large commercial and industrial structures such as hotels, office buildings, and factories. Data Loggers are primarily used to collect detailed electrical energy consumption at the point of use and associated parameters (kilowatts, amperes, volts, etc.), but they can also be configured to measure thermal energy (BTUs), solar energy, and other energy-related functions. For example, Data Loggers may be used to collect data on natural gas flow, indoor and outdoor temperature and relative humidity, and elapsed run time of motors, air conditioners, and other energy consuming equipment.



*Multi-channel monitoring provides real-time data on energy usage.*

The original PNL-developed Data Loggers underwent further development under a joint agreement between PNL and Synergistic Control Systems, a small American manufacturing firm in New Orleans. Together, they combined PNL's technology with Synergistic's manufacturing and marketing capabilities. In 1988, Synergistic delivered the first commercially available Data Loggers—known as the C180 Meter/Recorder. In 1991, PNL received a Federal Laboratory Consortium Award for Excellence in Technology Transfer for its work on the Data Logger.

From the first prototype of the technology, which required only a $25,000 investment on the part of BPA and DOE to design and produce, more than 2500 Data Loggers have been sold domestically and internationally. Electric utilities, energy service companies, universities, and major federal agencies employ Data Loggers to inexpensively collect accurate, verifiable data on energy end-use consumption. Utilities use the information to better plan and manage energy conservation programs. Engineers use this information to build more energy-efficient heating, cooling, and lighting systems. Energy service companies use the data to identify the most significant targets for reducing the energy bills of their clients through investments in energy efficiency.

Sources:

Fishbaugher, M.J. 1988. "Development and Transfer of Energy Use Monitoring Technology at the Pacific Northwest Laboratory," PNL-SA-15902, Paper presented to the International Congress on Technology Exchange, October 18.

Sandusky, W.F., Pearson, E.W., Miller, N.E., Crowder, R.S., Parker, G.B., Mazzucchi, R.P., Stokes, G.M., Thomas, J.J., Pratt, R.G., Schuster, G.J., Halverson, M.A., Stoops, J.L., Peterson, F.J., Gillman, R.A., Stokes, R.A., and Hauser, S.G. 1993. "ELCAP Operational Experience." In Energy and Buildings, Volume 19 Number 3, pp. 167-178, Elsevier Science Publishing Co. New York, New York.

Synergistic Control Systems. 1995. "Integrated Metering Products." Synergistic Control Systems, Inc., New Orleans.

# Fact Sheet

## ROADS IN SEASONAL FROST AREAS*

### PROBLEM

Pavements in cold regions commonly deteriorate much more rapidly than those not subject to the environmental effects experienced in adverse climatic areas. Environmentally induced damage has not been studied as comprehensively as has load-induced damage to pavements.

### DESCRIPTION OF THE PRODUCT

The objective of this work was to enhance the design, construction, and evaluation of roadway pavements in seasonal frost areas. This was to be accomplished by constructing, instrumenting, and monitoring the performance of 20 test sections constructed as part of the Minnesota Road Research Project (Mn/ROAD). Anticipated products were validated pavement design and evaluation methods for pavements in cold regions.

### STATUS OF PROJECT

The CPAR-related work was initiated in April 1990 and was originally scheduled for completion in September 1992. Because Mn/ROAD is a research project, well-controlled construction was necessary to ensure accurate results. The subgrade material is highly reactive to moisture and, as the 1990 and 1991 construction seasons were much wetter than normal, construction was not completed until September 1993. Instrumentation hookup was completed in early 1994 and the road was opened to traffic in July 1994. Because the study had already been in place for four years and failures were not anticipated for two to five years, it was decided to terminate the study in December 1994. Although new pavement design and evaluation procedures were applied to the test sections, the CPAR effort was terminated before the new methods could be thoroughly validated and refined. The Minnesota Department of Transportation (Mn/DOT) continues to monitor the test sections.

### PARTNERING

This project was a Corps of Engineers Construction Productivity Advancement Research (CPAR) project, which is a cost-shared, cooperative research program designed to enhance the competitiveness of the United States construction industry. The U.S. Army Cold Regions Research and Engineering Laboratory (USACRREL) was partnering with the Mn/DOT.

### COST SHARING

The total cost of the project, $4,520,000, was shared by USACRREL ($365,000) and the Mn/DOT ($4,155,000).

### POINTS OF CONTACT

Dr. Richard L. Berg, USACRREL, 72 Lyme Road, Hanover, NH 03755-1290
603-646-4335

Mr. Richard Sullivan, Mn/DOT, 1400 Gervais Street, Maplewood, MN 55109

* *This fact sheet supersedes* The MN Test Road-MN/Road, *dated November 1992.*

April 1995

US Army Corps of Engineers
Cold Regions Research & Engineering Laboratory

CRREL, 72 Lyme Road, Hanover, NH 03755-1290

US Army Corps of Engineers ®
Construction Engineering Research Laboratories

P.O. Box 9005
Champaign, IL 61826-9005

Public Affairs Office
Phone (217) 352-6511
http://www.cecer.army.mil

# Fact Sheet

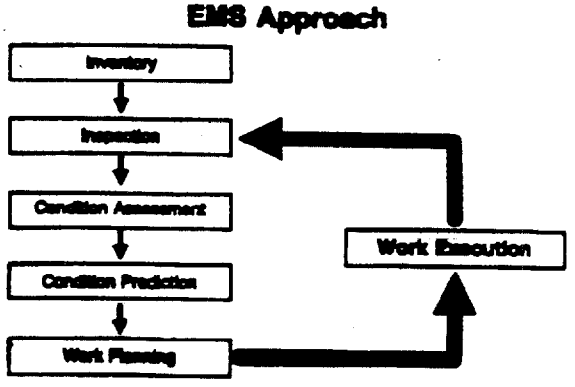
May 1996

(FL 32)

## MICRO PAVER PAVEMENT MANAGEMENT SYSTEM

### The Problem

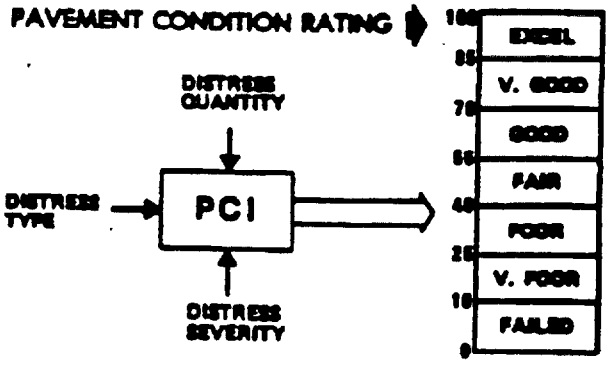
Reduced funding for pavement maintenance and repair (M&R) requires that existing funds be used more effectively. A pavement management system is needed to assist military and civilian organizations in optimizing the use of funds available for pavement repair.




**Micro PAVER System**

### The Technology

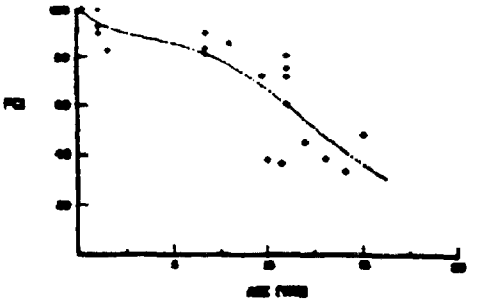
The U.S. Army Construction Engineering Research Laboratories (USACERL) developed the Micro PAVER Pavement Management System to optimize the use of pavement repair funds. The system, which uses state-of-the-art engineering techniques, was developed through funding from the U.S. Army, U.S. Air Force, U.S. Navy, Federal Aviation Administration (FAA), Federal Highway Administration (FHWA), and the American Public Works Association (APWA). Micro PAVER was developed for use on IBM-compatible personal computers.




**PCI Concept**

An important factor in optimizing the use of pavement repair funds is the pavement condition, which is determined by using the Pavement Condition Index (PCI). The PCI is an objective and repeatable rating of pavement condition based on observable distress. PCI procedures for roads, parking lots, and airfield pavements have been developed. The PCI for airfields has become an American Society for Testing Materials (ASTM) Standard Test Method (ASTM designation: D5340-93).

The pavement condition prediction is performed using the USACERL-developed family analysis modeling technique. With this technique, pavements having similar characteristics are first grouped into families. Then, a different deterioration curve is developed for each family. Condition prediction for each pavement section is based on the family to which it is assigned.



**Typical Family Curve**

Benefits/Savings


**PCI/Budget Consequences**

Network-level management tools help personnel develop rational budget requests and allocate optimal budget assignments. An important output at the network level is the consequence of various budget scenarios on the PCI. This technology results in maximized pavement conditions using available funds.

Status

Micro PAVER subscribers include cities, universities, consultants, airports, and others. The support centers located at the University of Illinois at Urbana-Champaign (UIUC) and with the APWA sell the Micro PAVER program and provide strategic support, i.e. phone consulting and training, to its users. USACERL provides APWA and UIUC with updated versions of the program. These two centers have established fees for distribution and support of the program.

The latest Micro PAVER version released is V3.2G, August 1995. One recent improvement is the ability to use hand-held computers in the inspection process. Users can enter inspection data in the field and then later upload the information into the Micro PAVER database automatically. This eliminates the tedious manual entry of the information into the database days or weeks after the inspection was done.

Another improvement is an interface to a Geographic Information System (GIS). When GIS technology is used to view information in the Micro PAVER database, the user gets a visual map that shows the different properties of the pavement. New versions of Micro PAVER, which include V3.3G (DOS) and Version 4.0 (Windows), are due for release in the summer of 1996.

For information about roads and parking lots, USACERL Technical Report TR M-90/05 is available through USACERL, and Army Technical Manual TM 5-623 is available from the U.S. Army Engineering and Housing Support Center. For information about airfield pavements, FAA Advisory Circulars AC 150/5380-6 and AC 150/5380-8, Air Force Regulation 93-5, and ASTM D 5340-93.

Points of Contact

USACERL POC is Dr. M. Y. Shahin; toll-free 800-USA-CERL, ext. 7453; FAX 217-373-6740; e-mail m-shahin@cecer.army.mil; or USACERL, ATTN: CECER-FL-P, P.O. Box 9005, Champaign, IL 61826-9005.

The UIUC Support Center can be reached at 217-333-2882; or UIUC, Conferences and Institutes, 3028 East John Street, Suite 202, Champaign, IL 61820.

The APWA Support Center can be reached at 814-472-6100, ext. 591; or APWA, 106 West 11th Street, Suite 1800, Kansas City, MO 64105-1806.

NATIONAL SCIENCE FOUNDATION
4201 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22230

**Agency :** NSF

**Program Title:** Earthquake Hazard Mitigation /
Vulnerability of Water Supply Systems

**Products:** A GIS-based computer program and methodology that simulates the operation of complex water supply systems under extreme events such as ground failure and pipe rupture during damaging earthquakes. Calibration of this software using the Auxiliary Water Supply System (AWSS) for the City of San Francisco. Development of suppression scenarios for fires that follow earthquakes.

**Goals Impacted:** Reduce the vulnerability of major cities to damage by fires that follow earthquakes

**Quantification of Impact:** The software and associated methodolgy was used by City of San Francisco Fire and Water Departments to identify vulnerabilities in City fire fighting capabilities. As a consequence the City voted a $46.2 million upgrade to the AWSS in 1989 and was persuaded to retain its fire boat, which was to be sold. During the Loma Prieta earthquake of October 1989, fire broke out in the Marina District and water supplies were lost due to ground failure. However the fire was brought under control using the fireboat, Phoenix. Losses due to the fire were confined to one block in the Marina District and were considerably less than the $320 million loss in 1906, when virtually the whole city was consumed by fire following an earthquake.

Point of contact: Dr. William Anderson or Dr. S. C. Liu, NSF (703)306-1361

## United States Geological Survey (USGS)/Insurance Institute for Property Loss Reduction (IIPLR) Cooperative Project on Earthquake Insurance Issues:

### Partnership

The United States Geological Survey (USGS) and Insurance Institute for Property Loss Reduction (IIPLR) are creating a unique public/private partnership to provide a highly credible institutional framework for undertaking urgent, ongoing, and long-term state-of-the-art technology transfer projects on earthquakes in the framework of an "Information Wheel" for the benefit of the Nation.

The first meeting of the USGS/IIPLR partnership was held in Boston on September 24-25, 1996.

### United States Geological Survey

In the partnership, USGS, the Nation's "Institutional Geologist and Seismologist," will represent the principal institutional source of information on earthquake hazards (i.e., earthquake ground shaking, ground failure, surface fault rupture, and aftershocks), probabilistic ground shaking hazard maps used in national model building codes and land use criteria, and real-time seismic monitoring systems. Although not the primary or sole source of information of the topical areas of vulnerability, property damage, and property loss reduction, USGS, as part of its mission in the National Earthquake Program, has worked and continues to work cooperatively with its partners in other Federal agencies, state geological surveys (e.g., California Division of Mines and Geology), academia, and consulting companies to generate loss estimates and to contribute basic information to advance the state-of-the-art on these topics.

### Insurance Institute for Property Loss Reduction

In this partnership, IIPLR, formed in 1994 as the successor to the former National Committee on Property Insurance, will have an unique position of responsibility and influence on behalf of more than 67 insurance groups and others within the financial sector. IIPLR will be the representative of and conduit to the insurance industry and the Nation's primary private-sector advocate for property loss reduction from earthquakes, wind, hail, and other perils. Seeking to foster the enactment and enforcement of existing mitigation measures such as better building codes and land use planning in communities throughout the Nation, IIPLR will also be a champion for long term continuing education of professionals through authoritative publications written in a simple and understandable format and conferences that link earth science with actuarial science and researchers with practitioners.

## COOPERATIVE PROJECTS

Recognizing that there is not enough time or resources to do all the things that are needed, USGS and IIPLR will focus on one or more cooperative projects each year that provide needed information and contribute to the urgent national goal of fostering property loss reduction from earthquakes. For each cooperative project, USGS and IIPLR will serve, respectively, as the hub and conduit of the "Information Wheel," working together to make certain that the short - and long-term information needs of the property casualty insurance industry are known and addressed within a priority framework that is consistent with the missions of USGS and IIPLR.

Examples of possible cooperative projects under consideration include:

1.) Cooperative research to demistify the "Black Box" of loss modelers. The "Black Box" represents an area of focus where the insurance industry can receive significant benefit/cost for an investment in cooperative research to increase understanding of it. USGS, by virtue of its unique role since 1977 in the National Earthquake Program and responsibility under Public Law 101-614 for orgainizing comprehensive postearthquake investigations encompassing earth science, engineering, health care, and social service studies, already serves as the hub of an extensive "Information Wheel that is essential input to the "Black Box" of loss modelers and at the core of risk assessment and loss estimation.

2.) Monographs and books on specific topics associated with the "Black Box" and with "Hazard Assessment and Mitigation." Individual monographs should treat specific scientific and technical topics that would improve understanding of and add to the value of answers obtained from the black box and advance hazard assessment and mitigation. They should include information needed to relate ground shaking and ground failure hazards to vulnerability and property damage more accurately than at present; namely, the value added by considerations of seismicity, transfer of stress, source directivity, earthquake potential, magnitude, proximity of the earthquake source to an urban center, and the effects of local soils and rock on ground motion, ground failure, and potential destructiveness of buildings and lifelines. The uncertainty in these parameters, both because buildings and lifelines. The uncertainty in these parameters, both because of randomness and ignorance, is a critical topic because of its contribution to the imprecision and lack of reliability in the loss estimates and the indecisiveness for

mitigation.

Books should follow monographs in time and be designed for educational activities. Two examples are the comprehensive treatises produced by Karl Steinburgge, with support from Skandia, and by Herbert Tiedeman, with support from Swiss Reinsurance.

3.) A series of authoritative "Technical Notes on Earthquake Insurance Issues."
These short articles should deal in an integrated way with scientific technical, administrative, political, legal, and economic (i.e., STAPLE) issues associated with the hazard, built, and policy environments of earthquake insurance. They can range from descriptions of the unique hazard environments of each of the earthquake prone regions of the Nation, to discussions of the perceived risk (built environment), to the existing and emerging options for property loss reduction (policy environment).

4.) Real time information flow and executive briefings after a damaging earthquake.
We should improve the timing and availability of accurate information for the insurance industry after an earthquake disaster. The USGS has access to all earthquake related information because of its responsibilities and supporting roles in conjunction with the National Earthquake Program, The National Earthquake Information Center, global, national and regional networks, and postearthquake investigations.

5.) Annual meeting.
We should be able to multiply our influence by bring together at least once per year the foremost thinkers in the fields of earth science, actuarial science, economics, earthquake engineering, urban planning, and other relevant disciplines. Such meetings will increase understanding and multiply the number of champions throughout the Nation calling for earthquake property loss reduction.

## URGENCY

The key will be our focus on the joint activities that will ,make a difference in the loss potential throughout the Nation. The partnership will seek to foster throughout the Nation increased use of scientific and technical information on earthquakes by loss modelers and by decision makers in policy decisions as a means to reduce property losses and societal impacts from earthquakes over both the short- and the long-term. There is a very real sense of urgency to this work because of the growing knowledge bases on earthquake hazards on the one hand and the growing concentrations of people who are earthquake illiterate and not capable of using the available information and the increasing property values in earthquake prone regions on the other hand.

# Collaboration Opportunity

ALUMINUM BRIDGES

At least 9 aluminum bridges have been built in the United States. Relatively high material cost was offset by ease of fabrication, reduced transportation and erection costs and lower lifetime maintenance costs. These bridges, built between 1958 and 1963, have performed well and some remain in service. Similarly aluminum bridge decks have demonstrated lives of 30 years or more.

Aluminum's lightweight (one-third as much as steel) reduces structural dead load and often enables prefabrication and rapid installation, thereby reducing construction or repair/maintenance downtime. Durability and corrosion resistance combine to provide unique advantages. Aluminum, when exposed to air, forms a protective oxide film that effectively protects the surface from corrosion. Alloying further extends aluminum's useful life in severe environmental applications. Aluminum is readily available because of world oversupply in production and decreased military use in the USA.

To accelerate development and confirm findings through independent analysis, Reynolds Metal Company formed a Cooperative Research and Development Agreement (CRADA) with the U.S. National Laboratory (ORNL) in Oak Ridge, Tennessee, in April 1995. The CRADA will help to validate the company's technology and refine its aluminum bridge deck panel system for commercial use. The five-year agreement calls for the ORNL to focus on verification and evaluation through the use of its vast testing experience and manufacturing expertise.

Independent of the CRADA, Reynolds will participate in pilot bridge projects in Pennsylvania and Virginia during 1996. Results will be shared with other state highway department to provide additional information on aluminum bridge deck applications. Discussions also are in process with other state Departments of Transportation and Thruway and Toll Highway authorities.

The advantage of aluminum is evident in the PA project where a 300 ft. long, one lane suspension bridge will have its vehicle load limit increased from 7 to 22 tons when the present deck is replaced with aluminum. VADOT will build more than one bridge and is working with FHWA to assist in funding the instrumentation and other unique features of these experimental installations. The intent is to develop more cost-effective structural configurations.

Contact: Thomas J. Pasko, Jr., FHWA Headquarters, 703/285-2034. (The Federal Highway Administration R&D offices are assisting in developing experimental installations where this technology can be evaluated).

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Construction Engineering Research Laboratories

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Public Affairs Office
Phone (217) 352-6511
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# Fact Sheet

May 1996 (FL 34)

## SMART TAGGED COMPOSITES FOR INFRASTRUCTURE APPLICATIONS

### The Problem

Deterioration of structures due to corrosion is a great contributor to the billions of dollars lost annually to infrastructure decay. Additionally, use of heavy equipment mandated by the weight of massive concrete and steel based structural elements adds significantly to the cost of new construction, and to the difficulty of construction in remote regions. Use of advanced structural composites containing graphite and fiberglass reinforced resins can eliminate corrosion and reduce weight. However, increased acceptance of advanced composites in construction necessitates improved quality control/assurance (QC/QA) and in-service monitoring techniques to assure reliability.

### The Technology

The U.S. Army Corps of Engineers Construction Engineering Research Laboratories (USACERL), in joint research with the Society of the Plastic Industry Composite Institute (CI), is developing technology to establish the quality of advanced composite materials through active and passive tagging. Tagging involves embedding micron-size sensors particles into materials, such as composites, concrete structures, or adhesive layers, to form and integral. These embedded (or tagging) particle sensors interact with their host structures and generate certain types of measureable signatures which may be correlated with structural information, such as internal stress, strain, temperature, voids, chemical degradation, etc. The evaluation of these smart composites can be made during fabrication or in-service to provide information on structural health of the composite.

Active tagging uses an external energy source, such as a mgnet, to energize the embedded tag particles. The micro-mechanical interaction between the activated tags and the host structures results in a measurable signature which can be picked up with various conventional transducers and analyzed to determine internal material conditions.

Passive tagging examines the uniformity of distributive parameters such as density, degree of polymer cure, etc. For passive tagging, ferromagnetic particles can be mixed with the composite matrix materials, such as a vinyl ester resin. After the composite is formed, the distribution of the tagging particles may be detected using techniques such as eddy current. The distribution of the tagging particles can be related to the uniformity and properties of the matrix material.

These technologies will lead to self-diagnostic technologies in which the structure (or component) senses and reports aberrant performance and possibly corrects it by incorporating adaptive mechanisms. Smart tags capable of initiatin composite self-repair mechanisms by release of specific chemicals are also included in this research.

Benefits/Savings

Smart tagged structural polymer based composites can be used to replace steel and steel reinforcing in civil structures to eliminate corrosion as a deterioration mechanism, drastically reducing the cost of maintenance. The lighter weight of many advanced composite structural elements. Often coupled with environmental advantages and lower energy consumption during fabrication, offer advantages in erection and shipping costs, especially in remote locations. Correlation of signatures from embedded active and passive tags with composite properties will make analysis of information on the internal health of the composite possible. State of stress, presence of internal voids, deliminations, or cracks, are among the information expected to be capable of determination in-situ. Health monitoring, effectiveness of repair, accurate prediction of remaining service life, and extended safe service life are all possible by further development of these concepts for facility construction applications. Smart structures (or components) that sense and report aberrant performance and possibly correct it using self-repairing mechanisms, will become reality.

The result will be a greater reliability of structural composite materials in service, allowing more infrastructure applications to take advantage of lower maintenance cost, lightweight materials. The resulting increase in applications will expand interest, causing development of more refined design, analytical, production and fabrication procedures. Ultimately both residential and industrial construction will benefit.

Status

This research and development (R&D) is a joint government/industry program. CI and 11 compsites industry organizations join USACERL in work on the project. These companies will fund significant portions of the R&D, including much of the actual materials fabrication and testing at their facilities. Promising tag materials have been selected, tag interactive models have been developed, and fabrication of lab samples of tagged composites has been initiated.

Point of Contact

USACERL POC is Dr. R. Quattrone, COMM 217-373-6744; toll-free 800-USA-CERL; FAX 217-373-6732; e-mail r-quattrone@cecer.army.mil; or USACERL, ATTN: CECER-FL-M, P.O. Box 9005, Champaign, IL 61826-9005.

NATIONAL SCIENCE FOUNDATION
4201 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22230


## Design and Construction of Advanced Composite Material Structures by E.T. Techtonics, Inc.

**G. Eric Johansen, P.E.**
**President**
**E. T. Techtonics, Inc.**
**213 Monroe St.**
**Philadelphia, PA 19147**

**With SBIR funding from the National Science Foundation, E. T. Techtonics, Inc., Philadelphia, PA has developed, tested and commercialized a new advanced composite material building system (PRESTEK) which has been used in more than 40 construction projects to date involving pedestrian/ equestrian/light vehicle type bridges and roof/canopy structures. The company has marketed 2 types of structural components; i.e. a prestressed beam-truss and a standard truss component. These members are constructed with E-glass/isophthalic polyester resin shapes and prestressed as required with kevlar cables. The longest bridge constructed to date using this system is at Staircase Rapids in Olympic National Park, Hoodsport, WA. The main span is approximately 80'-0" in length with the two smaller side spans 40'-0" and 50'-0". The talk will discuss this project in detail as well as other designs which include the Catholic University Canopy/Handicap Access Ramp in Washington, D.C., the University of Pennsylvania Mod 6 Removable Canopy and Catwalk System in Philadelphia, PA, the Point Bonita Lighthouse Bridges in San Francisco, CA and the Haleakala National Park Bridges in Maui, Hawaii.**

US Army Corps of Engineers

Construction Productivity Advancement Research (CPAR)

# Fact Sheet

Directorate of Research and Development
Attn: CERD-C
20 Massachusetts Avenue, N.W.
Washington D.C. 20314-1000
(P) 202-761-0257

A Corps/Industry Partnership to Advance Construction Productivity and Reduce Costs

AM-14
May 95

## Construction Materials From Commingled Waste Plastics

***Technology Challenge***

Over 8.4 billion pounds of plastic containers are produced in the U.S. each year, but unpigmented, high-density polyethylene (HDPE) milk jugs and polyethylene terephthalate (PET) soda bottles are currently the only plastics that can be economically recovered and recycled into new containers. Even if all available HDPE and PET containers were collected and recycled into new containers, over 6 billion pounds of waste plastics are not recyclable, given current recycling processes. Ideas to constructively use this supply of commingled (mixed) waste plastics led several manufacturers to begin producing plastic lumber products. Although these materials offer some advantages (e.g., natural resistance to rot and insect attack) over wood materials they are to replace, plastic lumber materials have significantly different mechanical properties than wood. The acceptance of plastic lumber materials for construction has, therefore, not been as rapid or overwhelming as originally hoped. A major barrier to acceptance is the lack of understanding of the property differences and the lack of material specifications and design guidance.

***Description of the Product***

The products of this research are plastic lumber and timber materials made from commingled waste plastics. These recycled plastic lumber and timber products are expected to be suitable for construction projects requiring a high degree of resistance to moisture, sunlight, or corrosion. Material specifications, test methods, and design guidance to appropriately specify and use plastic lumber products will also be developed.

***Status of Project***

Plastic lumber materials in various dimensions have been received from eleven different participant manufacturers and are undergoing mechanical property evaluations. These evaluations will be used to establish specifications and criteria standards to assure conformity of product. Three new American Society for Testing and Materials test methods (density, compression and flex) for plastic lumber materials have been drafted and are in the balloting process. Test methods to measure creep and impact resistance are also under development. A materials performance standard is in its fourth revision. Several small demonstration construction projects using plastic lumber materials have been completed or are near completion. Designs are currently being finalized for the construction of two

different pedestrian bridges. One of the bridges is to be erected in cooperation with a municipal park district and the other as part of the Tiffany Street Pier, a waterfront demonstration project constructed almost entirely of recycled plastic materials by the New York City Department of General Services (NYCDGS). The Tiffany Street Pier bridge was designed using a non-traditional design approach relative to typical wood/timber construction. This non-traditional design approach should enable structures made from plastic lumber products to be cost competitive with wood on a first-cost basis, and not just in the lifecycle.

***Partnering***

| | |
|---|---|
| Laboratory: | U.S. Army Construction Engineering Research Laboratories (USACERL), Champaign, IL |
| Industry Partner: | Rutgers University, New Brunswick, NJ |
| Participants: | Consortium of plastic lumber manufacturers |
| | Consortium of other supporting public and private agencies/organizations |

***Cost Sharing***

The total cost of the project is $869K. The industry partner share is $519K and the laboratory share is $350K.

***Point of Contact***

Rutgers POC is Dr. Thomas J. Nosker, COMM 908-445-3632; or Rutgers University, Center for Plastics Recycling Research, Building 4109, Livingston Campus, New Brunswick, NJ 08903.

USACERL POC is Mr. Richard Lampo, COMM 217-373-6765; toll-free 800-USA-CERL; or USACERL, ATTN: CECER-FL-M, P.O. Box 9005, Champaign, IL 61826-9005.

NIST

BUILDING AND FIRE RESEARCH LABORATORY

# Success Story

## Computer Program BLCC used to evaluate chiller replacements for Federal buildings

The Department of Energy (DOE), the General Services Administration (GSA), and the five major domestic vendors (Trane, Carrier, York, McQuay, Dunham-Bush) that produce water-cooled chillers are cooperating on establishing a Basic Ordering Agreement (BOA) to simplify and reduce the costs of procuring chillers using ozone-friendly refrigerants to replace existing CFC-based systems in federal buildings. It is estimated that 4000 chillers will be replaced in this effort. As the underlying technical requirement, DOE has developed a generic chiller specification that requires selection based on lowest life-cycle cost rather than lowest first cost. The specification incorporates the NIST LCC methodology, developed to support DOE's Federal Energy Management Program, and the NIST BLCC (Building Life-Cycle Cost) computer program for calculating the life-cycle costs of alternative building systems. The BOA for chillers, a unique procurement vehicle for major industrial and capital equipment, is possible because of the Federal Acquisition Streamlining Act of 1994 and the recent Federal Acquisition Regulations concerning commercial procurements. Federal agencies gain by reducing the chiller ordering process to about 30 days and keeping total procurement costs to less than 2%. DOE's Office of Defense Programs estimates that savings of over $2.5 billion throughout the government will result from this process and the resultant reductions in life-cycle energy costs. Environmental benefits are realized through reduced emissions because of more energy efficient chillers and the use of refrigerants friendly to the stratospheric ozone layer. It is GSA's expectation that the formal notice of the basic ordering agreement would appear in the Commerce Business Daily in mid-spring 1996.

Contact:

Steve Petersen
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# Technology Development

Office of Energy Efficiency and Renewable Energy

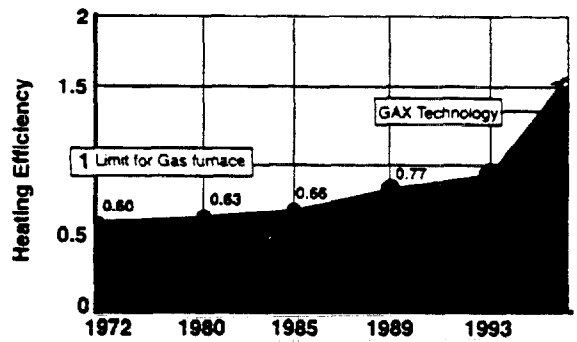
## National GAX Program

The U.S. Department of Energy (DOE) and Oak Ridge National Laboratory (ORNL) formed a partnership with industry to develop an improved heat pump design that will provide more efficient heating and cooling at lower cost and reduce risk to the environment. The generator-absorber heat exchange (GAX) cycle is a thermally-activated heat pump technology that uses a heat absorption process, rather than refrigerant vapor compression, to provide comfort heating and cooling. Industry partners in this development process include Phillips Engineering Company, United Technologies Carrier Corporation, and the American Gas Cooling Center.

In 1982, DOE requested proposals for the development of new heat absorption cycle technologies. Phillips Engineering responded and began research and development of a new natural-gas-fired, ammonia-water heat pump design. In 1993, Phillips released the new design to Carrier for review. After testing, Carrier decided the new design was potentially marketable, acquired a worldwide license for the technology, and began concerted efforts to introduce the new heat pump to the market by 1997. The American Gas Cooling Center is developing a utility consortium to facilitate adoption of the GAX technology, while DOE/ORNL is providing technical support and development guidance, leading the effort to achieve even higher efficiencies. All parties are sharing in the costs of development.

In the GAX process, a mixture of water and ammonia is pressurized by a pump and heated over a natural gas flame. The ammonia boils out of the mixture and travels to a condenser, where it releases heat and turns back into a liquid. The cooled ammonia then travels to an evaporator where it picks up heat from the outside environment, providing space cooling. Converted back to vapor, the ammonia is then recombined with water, which releases heat. The heat from this reaction, as well as the heat produced by the condensing process, can be used for space heating. Aside from the natural gas burned in the process, the only other energy requirement is for electricity to drive the circulation pumps and fans.

**Efficiency of GAX Versus Conventional Gas Furnaces**




The new design offers improved heating and cooling efficiency because using natural gas avoids energy conversion and distribution losses (around 70%) incurred when electricity is used. This factor, plus lower maintenance costs due to fewer moving parts, results in lower costs for the consumer. GAX technology also means improved protection of the environment, because benign refrigerants (ammonia and water) replace CFCs and HCFCs used in conventional heat pumps and air conditioners.

Heating and air conditioning accounts for 60 percent of all the energy used in residential buildings throughout the United States. With applications in light commercial as well as residential buildings, thermally-activated heat pumping technologies such as GAX could by 2010 help save up to 0.09 quads per year (based on an electric generation heat rate of 11,000 kWh) and save consumers an estimated $17.6 billion in utility bills. DOE/ORNL technical leadership and coordination of the GAX program has sped up the process for bringing this technology to the marketplace, ensuring development of a product that can provide significant energy and cost savings while benefiting the environment.

*Sources:*
ORNL Reports: ORNL/CON-410, CON-412.
U.S. National GAX Program, brochure.
"Thermally Activated Heat Pumps, What's New In Building Energy Research," U.S. Department of Energy Office of Building Technologies, May 1995.

US Army Corps of Engineers

Construction Productivity Advancement Research (CPAR)

# Fact Sheet

Directorate of Research and Development
Attn: CERD-C
20 Massachusetts Avenue, N.W.
Washington D.C. 20314-1000
(P) 202-272-0257

A Corps/Industry Partnership to Advance Construction Productivity and Reduce Costs

Fact Sheet CP-6
19 Jan 1995

## QUALITY CONTROL OF CONCRETE BY HEAT SIGNATURE AND MATURITY METHODS

TECHNOLOGY CHALLENGE. Current methodologies for job site quality control of concrete mixtures rely on technologies developed several decades ago. Several days to several weeks are required to obtain specific information on concrete quality from tests on hardened concrete. Modern computer technology along with advanced concrete technology will allow on-site evaluation and monitoring of concrete quality as well as selection of the best mixture proportions and curing schedules for a given placement.

DESCRIPTION OF THE PRODUCT. The Quadrel™ integrated software/test equipment system is a computer-aided engineering tool providing concrete quality control and quality assurance testing, simulation forecasting of in-place performance, and data management functions including mixture economics and user-defined graphing capabilities. The Windows-based software application works in a fully integrated manner with the Quadrel™ computerized datalogger and the Qdrum™ calorimeter. The system makes use of the maturity principle, which describes the strength development of concrete in terms an equivalent age value for the combined effects of time and temperature.

STATUS OF THE PROJECT. Quadrel™ was first commercially released in October 1993. An extensive database of test data were generated in the research laboratories of the Waterways Experiment Station (CEWES), at the Greater Pittsburgh (Pennsylvania) Airport Project, at one of the Chicago area's largest concrete producers, and at a commercial testing laboratory. These data were used to develop the algorithms in the Quadrel™ system.

PARTNERING. The industry partner was Digital Site Systems of Pittsburgh, Pennsylvania. Contributions were made by Mellon Stuart Dick Enterprises of Pittsburgh, Pennsylvania, and Material Service Corporation of Chicago, Illinois. The laboratory partner was Waterways Experiment Station of Vicksburg, Mississippi.

COST SHARING. The total cost of this research was $600K shared equally between the industry and laboratory partners.

POINT OF CONTACT. Industry: Dr. Farro Radjy, Digital Site Systems, 4516 Henry Street, Suite 305, Pittsburgh, PA 15213. Laboratory: Mr. Mike Hammons, CEWES-GP-Q, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199. The Quadrel™ system may be acquired from Digital Site Systems. A final technical report may be obtained from CEWES.

# Fact Sheet

## ANTIFREEZE ADMIXTURES FOR COLD-WEATHER CONCRETING

### PROBLEM

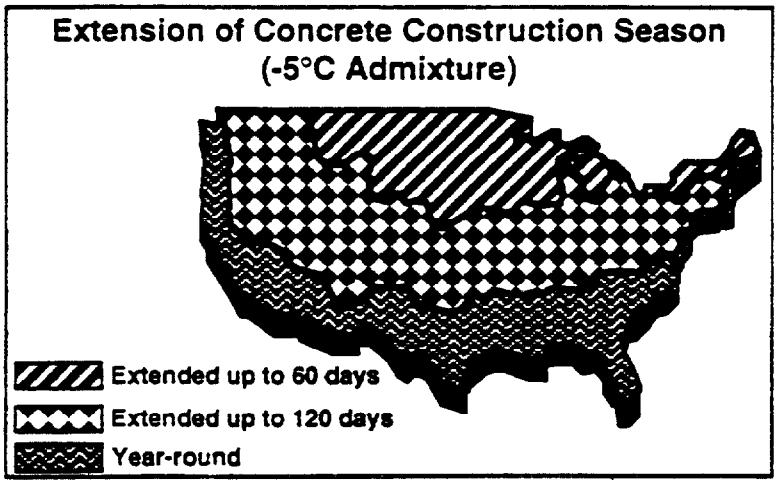
Concrete is the backbone of modern construction. Construction traditionally has been avoided during winter because low temperatures slow the strength development of concrete to unacceptable levels. Heat, insulation, and enclosures are needed to promote concrete strength when temperatures fall below 5°C and to protect immature concrete from freezing at lower temperatures. The energy cost for concrete thermal protection is estimated to be $800 million per year.

### SOLUTION

Develop chemical admixtures that depress the freezing point of mix water and promote concrete strength at low temperatures.

### RESULTS

CRREL has worked with private industry to develop prototype admixtures that protect concrete down to –5°C, temperatures at which normal concrete suffers irreparable damage. The work was conducted under the authority of the Corps of Engineers Construction Productivity Advancement Research (CPAR) program, which is a cost-shared program between the Corps and the U.S. construction industry. Currently, two prototype admixtures—one from Master Builders, Cleveland, Ohio, and the other from W.R. Grace, Cambridge, Massachusetts—have been brought to the threshold of commercialization. Expectations are for these admixtures to be marketed within the next year or two.




Antifreeze concrete will:

- Extend the construction season
- Reduce winter costs
- Increase winter employment

### CONTACTS


Charles J. Korhonen
CRREL
603-646-4438
Fax 603-646-4640

Brian Caine/Phil Dyer
Master Builders
216-831-5500
Fax 216-831-6053/3470

Tim Durning
W.R. Grace
617-498-4493
Fax 617-498-4313



December 1995

US Army Corps of Engineers
Cold Regions Research & Engineering Laboratory

CRREL, 72 Lyme Road, Hanover, NH 03755-1290

US Army Corps of Engineers

Construction Productivity Advancement Research (CPAR)

# Fact Sheet

Directorate of Research and Development
Attn: CERD-C
20 Massachusetts Avenue, N.W.
Washington D.C. 20314-1000
(P) 202-761-0257

A Corps/Industry Partnership to Advance Construction Productivity and Reduce Costs

AM-13
May 95

## High Performance Ultra-Light Concrete Masonry Unit

***Technology Challenge***

Due to the heavy weight of currently used concrete masonry units (CMU), a serious challenge faces the masonry industry. Early retirement of younger masons due to back injuries and other disabilities, as well as lack of young people entering the trade, has caused the average age of masons to increase from 45 years in 1978 to 54 years in 1988. The goal is to develop CMU of comparable quality to existing normal weight CMU, but with the weight reduced by as much as 50% and with the cost of the constructed facility reduced by as much as 23%.

***Description of the Product***

This project merges the rapidly developing high-strength concrete technology with lightweight concrete technology to produce an optimum unit for construction of reinforced masonry walls. Traditional vibro-press technology with full automation is retained as the core of masonry production because of the already established success of this technology and to ease adoption of the research results for the majority of U.S. plants. The block mix consists of the standard materials sand and cement, as well as expanded shale, fly ash, silica fume, and some admixtures. The block shape has also been optimized to minimize materials.

***Status of Project***

This project is nearly complete. Unit shape was optimized using finite element analysis to minimize the cross sectional area of an A-shaped unit, which was determined the most efficient for reinforced masonry construction. The optimized shape was subsequently modified to improve machinability, handling, and to reduce breakage during transportation. Unit compression and durability tests have been conducted throughout to determine unit properties. A test retaining wall based on the optimized unit shape and a trial mix design was constructed in Omaha in August 1992. Final reports will be available from both industry and laboratory partners in early 1995.

***Partnering***

| | |
|---|---|
| Laboratory: | U.S. Army Construction Engineering Research Laboratories (USACERL), Champaign, IL |
| Participants: | U.S. Army Corps of Engineers Missouri River Division |
| Industry Partner: | Nebraska Technology Development Corporation (as contracting agent for the University of Nebraska Center for Infrastructure Research (UNL-CIR)) |
| Participants: | Nebraska Concrete Masonry Association<br>Nebraska Masonry Institute<br>Masonry Contractors Association of Eastern Nebraska |

***Cost Sharing***

Total cost of the project is $498,000. The industry partner share is $250,000 and the laboratory share is $248,000.

***Point of Contact***

UNL-CIR POC is Dr. Maher Tadros, COMM 402-554-2980.

USACERL POC is Mr. Steven Sweeney, COMM 217-373-6793; toll-free 800-USA-CERL; or USACERL, ATTN: CECER-FL-E, P.O. Box 9005, Champaign, IL 61826-9005.

U.S. Department of Transportation
Federal Highway Administration

# Success Story

HIGH PERFORMANCE CONCRETE (HPC) BRIDGES

HPC is concrete with enhanced durability and, if needed, increased strength. Despite promising research results and the potential for cost savings, relatively little had been done before 1993 regarding the implementation of HPC in bridges in the United States. In July 1993, FHWA initiated its first HPC bridge project with TxDOT: the Louetta Road Overpass. Since that time, another HPC bridge project in Texas (the San Angelo Bridge) as well as HPC bridge projects in Virginia, Nebraska, and New Hampshire have begun.

The time has come to pass on this technology to other interested States. Toward the end, the first SHRP HPC Bridge Showcase will focus on the technical aspects of HPC and will highlight the two HPC bridges currently being constructed in Texas. The showcase is geared for the practitioner - how does one design and construct with HPC? Presenters will include TxDOT, FHWA, and University of Texas at Austin personnel, as well as consultants, concrete fabricators, and contractors. Because of the high level of interest, requests for attendance have been overwhelming and limited to invitation only.

The many benefits of High Performance Concrete (HPC) for bridges will be presented during the SHRP HPC Bridge Showcase, scheduled for March 25-27, 1996, in Houston, Texas.

Most bridge concrete has a strength of about 5000 psi, but the building code allows up to 10,000 psi. The use of the higher strength for prestressed girders allows the elimination of about 2 girders per bridge (say, from 9-7), or to span up to 1/3 more length, or to save about 1/3 the volume of concrete.

Most of the needed technology is in the public domain and the challenges are in training, designing, quality control and fabricating, handling, and placement of the lighter bridge members. The stigma of possible increased risk must also be overcome. The technology may be applicable to about 1000 concrete bridges built per year in the USA and there is a potential savings of 5 to 10% from the reduction in the number of needed girders. If the bridge market can be developed, its improved technology market might reinforce the other concrete markets (industrial, high rise, etc) such that the quality of concrete in the US is significantly improved for all construction.

The Federal incentive for implementing this technology is that States can use their Federal Aid funds for construction and other special needs during construction (instrumentation, etc). They may also use their Federal Aid R&D funds for securing expertise (TxDOT is using researchers from University of Texas). Additionally, certain other costs may or may not be eligible for coverage through special grants directly from FHWA. FHWA staff experts are also available if requested.

Technical information on the showcase is available from Susan N. Lane, FHWA headquarters, (703)285-2111.

A video tape is tentatively planned on the subject.

US Army Corps of Engineers

# Fact Sheet

Directorate of Research and Development
Attn: CERD-C
20 Massachusetts Avenue, N.W.
Washington D.C. 20314-1000
(P) 202-272-0257

A Corps/Industry Partnership to Advance Construction Productivity and Reduce Costs

Fact Sheet AM-9
Date: 17 Jan 1995

## Evaluation of the Applications of DELVO Technology

TECHNOLOGY CHALLENGE: Current construction practices and methods of batching, mixing, and transporting concrete are dictated by the fresh properties of the concrete, and the duration those properties are maintained. DELVO, through its influence on the length of time that certain fresh concrete properties are maintained, has the potential to make a significant impact on the productivity of the U.S. construction industry by making possible different and potentially more practical approaches to transporting and placing concrete. It will also make more innovative and cost-effective concrete construction techniques possible. For example, concrete will be able to be transported great distances, to remote construction sites, thus eliminating the expense associated with mobilizing a portable batch plant. In addition, DELVO has the potential of making a major impact on pavement construction by greatly reducing or eliminating the number of construction joints which must be constructed at the end of a shift. Construction of these joints reduces the amount of time that a paving contractor can actually pave in any given day, and also create localized areas where pavement deterioration can occur and ride comfort is diminished. The use of DELVO in roller-compacted concrete (RCC) for mass concrete construction may permit a reduction in the number of lift joints which must undergo extensive and expensive cleanup. It will also permit bedding mortars and concretes to remain in a fresh state longer which will help assure greater bond and less seepage between lifts.

DESCRIPTION OF PRODUCT: Products to be produced include simplified procedures that will allow ready-mixed concrete producers to accurately and concisely determine dosage ranges of the DELVO admixture for a variety of concrete materials, applications, and conditions; and development of potentially new applications for DELVO technology including RCC, pavements, and lean mass concrete. Since DELVO is a chemical admixture system which takes advantage of a concrete producer's existing concrete batching and mixing plant, implementation of the technology requires very little investment in new equipment. The cost of using the technology is essentially the cost of the DELVO chemicals which are comparable to other concrete chemical admixtures used by the concrete industry today.

STATUS OF PROJECT: The project has been completed and a final draft report is currently in preparation. Results of an extensive laboratory evaluation of DELVO for same-day, overnight, and long haul applications indicate that DELVO provides a tremendous degree of flexibility with respect to hydration control of fresh concrete and that in many instances the resulting hardened properties of concrete containing DELVO actually improved. Cores taken from a full-scale RCC test section indicate that the joint shear strength of RCC containing DELVO is significantly greater than that of RCC containing no DELVO and only slightly less than lift joints which were treated with bedding mortar. Ready-mixed concrete demonstrations of DELVO technology were conducted in Louisville, KY and Phoenix, AZ.

PARTNERING: Industry Partner: Master Builders, Inc.
Laboratory Partner: USAE Waterways Experiment Station

COST SHARING: Total Project Cost: $610,000.00

Industry Cost: $310,000.00
Corps Costs: $300,000.00

POINT OF CONTACT: Industry: Mr. Gregory S. Bobrowski
Master Builders, Inc
23700 Chagrin Boulevard
Cleveland, OH 44122

Laboratory: Mr. Steven A. Ragan
USAE Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

# Fact Sheet

## FROST EFFECTS ON LANDFILL LINERS AND COVERS

### PROBLEM

Freezing and thawing reduce the effectiveness of compacted soil materials to keep water from seeping into landfills and to prevent leachates from polluting groundwater supplies. EPA guidelines require an additional common soil layer to protect compacted soil landfill covers from frost. *This extra soil layer costs an additional $16,000 per acre of landfill (approximately $325,000 for a typical 20-acre landfill).*

Previous studies by CRREL for the Department of Energy Uranium Mill Tailings Recovery Act (UMTRA) program have indicated that compacted soil materials are unsuitable for covering uranium mill tailing wastes unless they are protected from frost action. *Additional costs to the Government for frost protection at the UMTRA sites have exceeded $20 million.*

New design criteria, alternative materials, and standardized laboratory tests are essential to reducing these costs.

### SOLUTION

CRREL is studying this problem under the Corps of Engineers Construction Productivity Advancement Research (CPAR) Program. The work is being done in partnership with five private sector companies, including Waste Management, Inc. and CH2M Hill Engineers. Laboratory and field studies are being conducted on several soil materials, as well as on potential substitute geosynthetic composite materials (a thin layer of bentonite clay bonded to a synthetic membrane or sandwiched between two layers of synthetic fabric).

It appears that, when subjected to frost action, the manufactured composite materials have a superior performance to that of soil materials, with little or no additional cost. Laboratory and field studies will determine the appropriate materials and test methods.

### RESULTS

Field test sections have been built near Milwaukee, Wisconsin, and have been subjected to one winter of freezing. These sites are instrumented for temperature and in-place permeability measurements.

Test results on frozen samples show that the permeability of the clay materials increases by a factor of approximately 100 when subjected to freezing and thawing. Preliminary tests on the geosynthetic materials indicate that their performance is not adversely affected by frost action. Thus, millions of dollars may be saved if these new materials are used. *For one DoE UMTRA site alone, the cost savings could be $4 million.*

This CPAR study is being augmented by additional studies for the private sector. A study has been completed for Ardaman and Associates for a spill containment basin around a liquid fertilizer tank in Minnesota. A second study for Balsam Environmental Engineers, Nashua, New Hampshire, for an EPA superfund site near Springfield, Vermont, is just starting.

### CONTACT

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April 1993

US Army Corps of Engineers
Cold Regions Research & Engineering Laboratory

CRREL, 72 Lyme Road, Hanover, NH 03755-1290

**USDA Forest Products Laboratory**
**One Gifford Pinchot Drive**
**Madison, Wisconsin 53705-2398**

# Successful Commercialization of Forest Products Utilization Research

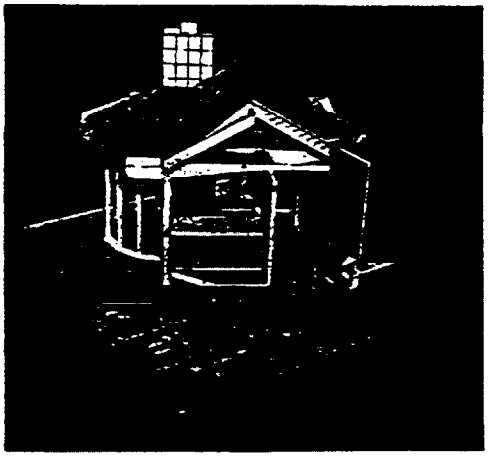
The USDA Forest Products Laboratory (FPL) in Madison, WI has been a center of excellence for research to promote conservation of wood and fiber resources. Among its many successes, there are products of collaboration with the University and Industry partners that result in commercialization. Here are a few examples:

- Southern Pine Plywood: Development of Southern pine plywood shifted part of the demand from Douglas-fir in the Pacific Northwest to other species in the South. Development of Southern pine plywood was the result of partnership between the USDA Forest Service research, the Southern pine industry and rural communities. As the result, there has been a growth of 3 plants in 1964 to 69 plants in 1990 producing Southern pine plywood.

- Oriented Strandboard (OSB): In the early 1970's, the USDA Forest Service initiated a major research program to develop technology for using forest residues in the manufacturing of OSB to respond to the Nation's demands for panel materials. This technology has been successfully commercialized by major forest products companies, and the prominence of OSB in the market today is clearly visible.

- Dynamic nondestructing testing device: Evaluating the strength of wood in various applications is no longer a guessing game. FPL has developed a a low cost stress rating technology which has now been used in affordable testing equipment to assure quality, safety, and value of buildings and constructions.

- Recycling of waste wood and paper: Waste wood and paper products constitute a significant part of municipal solid wastes going to landfills. The Forest Service goal is to reduce this waste stream by 50 percent. The FPL is working with its Industry and University partners to remove technological barriers to recycling of wood fibers. To date, there have been successful commercialization of Spaceboard (a structural fiber-oriented material), and wood/plastic composites that hold promise for applications in buildings and constructions.

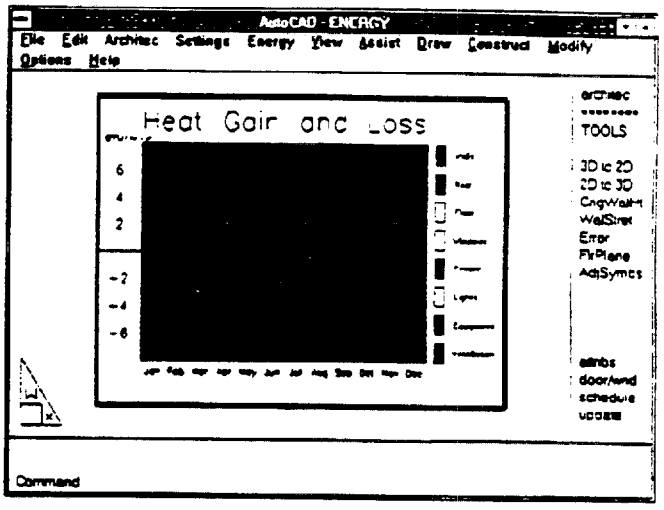


*This model house depicts the use of new recycled wood and paper products for housing. Use of recycled products has the potential to conserve resources, reduce land-fills, provide additional supplies of construction materials, and create jobs.*

# Success Story

Office of Energy Efficiency and Rewable Energy

## Pacific Northwest Laboratory's Softdesk Energy Helps Architects Build in Energy Efficiency at the Drawing Board




The U.S Department of Energy's Pacific Northwest Laboratory has joined forces with commercial and academic partners to create a software tool that could make every architect in the country an energy efficiency expert. The software tool, called Softdesk Energy, was designed by PNL, the University of Oregon, and Softdesk, Inc., the largest provider of architectural computer aided design (CAD) software in the country.

Softdesk Energy is the first energy analysis software developed to be part of an existing design software instead of operating as a cumbersome, stand-alone program. It's simplicity and ease of use should guarantee broad acceptance in the design community. The tool is installed on an architect's computer as part of his or her Softdesk Auto Architect software and is available through a scroll-down "energy" menu to provide energy analysis early in the schematic design stage of the design process when the greatest potential for energy savings in building construction occurs (over 40% of the potential savings).

By coupling the software with an existing commercial product, DOE is able to reach far more than just the typical 1,000 to 5,000 users of government energy analysis software. The software is immediately available to all of Softdesk's estimated 100,000 users, which represent well over half of the building designers in this country who use CAD.

The tool comes on one disc, is easy to install, and is so intuitive there is almost no learning curve - in stark contrast to previous energy analysis software packages that were separate programs requiring weeks of time to learn new coding languages and days to enter input data. Softdesk automatically infers information from the CAD drawing and previous uses. With a few simple selections on the architect's part, such as location (for climate data) and building use (office or residence), the program makes "educated" assumptions and can begin offering energy advice.

When the designer wants to see the results of a design decision, the software takes only seconds to generate a chart showing heat gains and losses for eight different building components, including lights, roof, windows, equipment, and ventilation, for each month throughout the year so the designer can see which components are contributing the most to loads. Architects who have never focused on energy efficiency before will now be able to build it in as a routine part of their work.

Softdesk Energy shows promise of significantly reducing building energy use because it encourages designers to build in savings during the schematic design stage of building construction when the majority (over 40%) of the energy savings are possible.

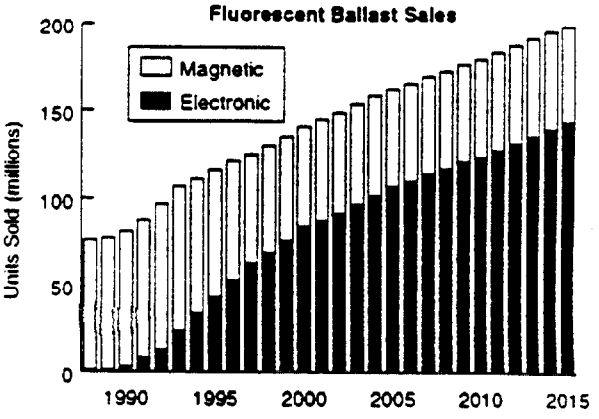
Fact Sheet

# Success Story

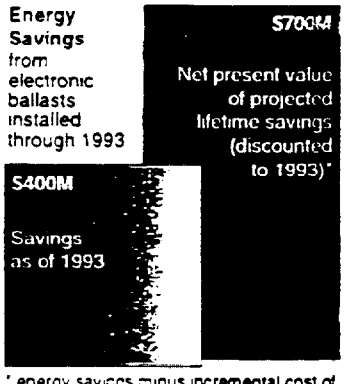
Office of Energy Efficiency and Renewable Energy

## Electronic Ballasts

In the late 1970s, Lawrence Berkeley Laboratory (LBL) and the U.S. Department of Energy (DOE) initiated a public/private effort to develop energy-efficient electronic ballasts for fluorescent lamps. By 1993, this $3 million DOE/LBL effort had produced an electronic ballast that had captured 23% of the fluorescent ballast market, with U.S. sales of approximately 25 million units.




Fluorescent lights require ballasts, which help start and then control the current flowing through the lamps. An annoying flicker, hum, and energy loss are the infamous hallmarks of the magnetic ballast, the industry standard for decades. Electronic ballasts eliminate flicker and hum, and save energy by reducing electrical losses in both the ballast and the lamps. Electronic ballasts can also be designed for dimming and can be made smaller and lighter than standard ballasts. In the late 1970s, with research on the electronic ballast just underway, LBL contracted with three small companies to produce commercial models of high-frequency electronic ballasts for conventional fluorescent lamps. After the ballasts were tested by LBL to assure compliance with specifications, they were installed at a demonstration site in a utility office (PG&E) in San Francisco. The results of these early demonstrations showed that electronic ballasts could operate satisfactorily in a typical building environment and reduce lighting energy use by up to 30%.




* energy savings minus incremental cost of efficient ballasts (7% real discount rate)

As a result of research efforts and continued quality improvements, the electronic ballast has developed from a laboratory curiosity into a proven and successful energy-efficient lighting technology. These new ballasts will likely replace magnetic ballasts in more than 75% of applications by the year 2015. The cumulative energy savings attributable to electronic ballasts from 1988 to 1993 is $400 million. With a federal investment in electronic ballast R&D of about $3 million, this represents a benefit/cost ratio of 133:1. For ballasts installed as of 1993, businesses and consumers will leverage a net savings of $700 million over the lifetimes of the ballasts, for a ratio of 230:1. This will grow to $13 billion for ballasts installed through the year 2015, for a benefit/cost ratio of 4300:1.


Sources:

"Energy Efficiency and Performance of Solid-State Ballasts." R. Verderber, S. Selkowitz, S. Berman. *Lighting Design & Application*, pp. 23–28 (April 1979).

"Energy Savings with Solid-State Ballasts in a Veterans Administration Medical Center." R.R. Verderber, O.C. Morse, A.A. Arthur, F. Rubinstein. *IEEE Transactions on Industry Applications* IA-18 (6), pp. 653–65 (November/December 1982).

*Advanced Lighting Guidelines*. C. Ely, T.M. Tolen, J.R. Benya, F. Rubinstein, and R. Verderber. DOE/EE-0008 (1993).

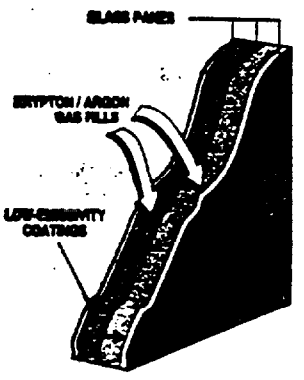
Fact Sheet

# Success Story

Office of Energy Efficiency and Renewable Energy

## Energy-Efficient Windows

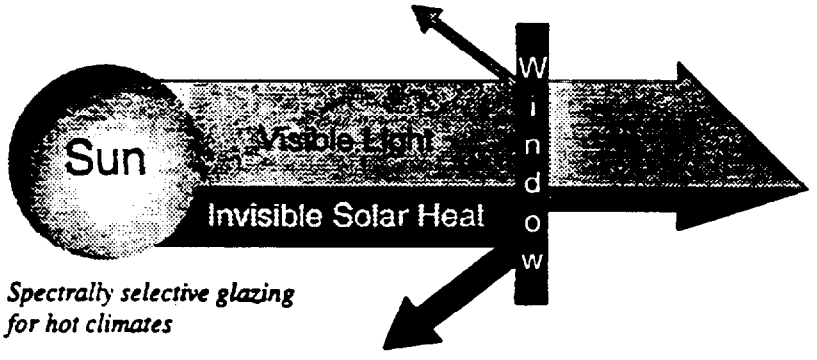
The energy lost through residential and commercial windows costs U.S. consumers about $25 billion a year, a sum comparable to the value of the oil delivered by the Alaska pipeline. To help the nation reduce this cost, Lawrence Berkeley National Laboratory pioneered the commercialization of "low-emissivity" windows, which reduce the wintertime energy lost through normal, double-glazed windows by 35%. More recent developments are helping to commercialize "spectrally selective windows," which reduce cooling loads in hot climates.



*Superwindow for cold climates.*

The development of these new windows started in 1976 when DOE began a program at LBL to examine the potential of new, more efficient window technologies. After almost 20 years of an R&D partnership with industry, that effort has resulted in sizable energy savings to U.S. building operators, and profits for window manufacturers.

In cold climates, low-emissivity coatings allow sunlight to enter while reflecting back to the interior the long-wave infrared radiation that accounts for more than half the heat loss. Although the principle of how these coatings work was understood before LBL became involved, no U.S. manufacturer had developed a commercial product. LBL awarded subcontracts to several firms and oversaw their development of prototype coatings and new, low-cost, thin-film deposition processes. The performance of the coatings was independently tested at LBL and a new computer model called WINDOW was developed to determine the best use of the coatings in the overall window system. This software package has been adopted as the engineering "yardstick" by the National Fenestration Rating Council for window performance rating and labeling across the country.



*Spectrally selective glazing for hot climates*

Thanks to LBL's close collaboration with window manufacturers, and a cumulative DOE investment of just $3 million, the market share for these advanced windows in 1993 reached about 35% of all windows sold in the U.S. The cumulative U.S. energy savings for windows installed as of 1993 was $760 million. U.S. businesses and consumers ultimately will save $17 billion from advanced window technologies installed through the year 2015, net of their extra capital investment. Spectrally selective glazings are just now entering the market and will contribute to these savings.

As an added benefit to the economy, the U.S. window industry enjoys a growth in sales of $630 billion each year, corresponding to the higher value of the efficient windows. The environment will also benefit: In 2015, energy savings from advanced windows will avoid the emission of 71 million tons of $CO_2$, 157,000 tons of $SO_2$, and 142,000 tons of $NO_x$.

Building AMERICA

# Overview: Building America Initiative

The Building America Initiative is an industry-driven program sponsored by the U.S. Department of Energy (DOE) for applying systems engineering approaches that accelerate the development and adoption of innovative building processes and technologies. The goal of the Initiative is to produce energy efficient, environmentally sensitive, affordable, and adaptable residences on a community scale. Field support is provided by the National Renewable Energy Laboratory (NREL).

As part of the Building America Initiative, DOE and NREL have established 4-year cost-sharing agreements with four broad-based housing industry teams. Over the life of the agreements, the teams will contribute more than $40 million of their own resources to the joint program. The teams are accelerating home-building energy innovations using a comprehensive systems engineering approach that provides direct testing and evaluation of the cost and performance benefits associated with new building technologies. In addition to energy systems, the teams are evaluating innovative design and delivery strategies, innovative building materials, and innovative construction systems.

Building America brings together all segments of the housing industry (designers, builders, developers, financial institutions, material suppliers, and equipment manufacturers). These industry groups have traditionally worked independently of one another, slowing development and adoption of new technologies. By working together using a systems engineering approach, decisions previously made independently can quickly be made with consideration for the entire design, manufacturing, and construction process, thereby increasing quality and performance without increasing cost.

In 1995, contracts were awarded to Building Science Consortium, based in Chestnut Hill, Massachusetts; Consortium for Advanced Residential Buildings, based in Norwalk, Connecticut; and Hickory Consortium, based in West Wareham, Massachusetts. All three teams include industry members from states across the nation.

These contracts represent the second phase of the Building America Initiative. In 1993, Building America's first phase established a partnership between DOE and the IBACOS

(Integrated Building and Construction Solutions) Consortium based in Pittsburgh, Pennsylvania. IBACOS has built two test homes in Pittsburgh and is continuing developmental work with the three new teams.

Each team is constructing test houses and implementing a strategy for developing neighborhood-scale projects that incorporate their systems innovations. DOE and NREL are providing the teams with energy-related expertise, with the goal of accelerating development of major systems innovations that will make the housing industry more competitive in the global market. The Building America Initiative is also supporting industry-driven research and development of critical "next generation" building systems identified by the industry teams.

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Building AMERICA

*Department of Housing and Urban Development*
*Policy Development and Research,*
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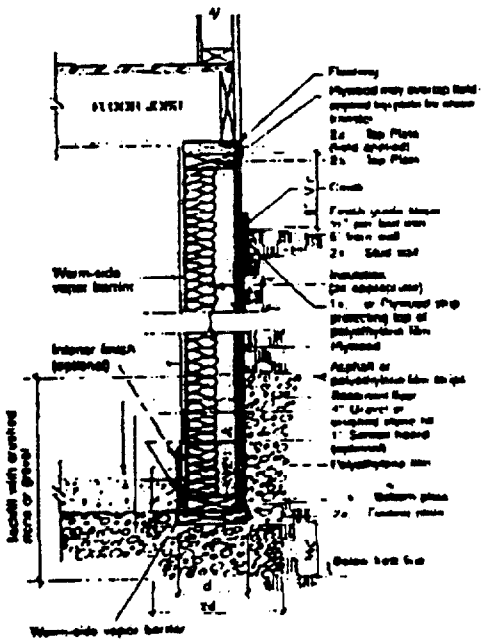
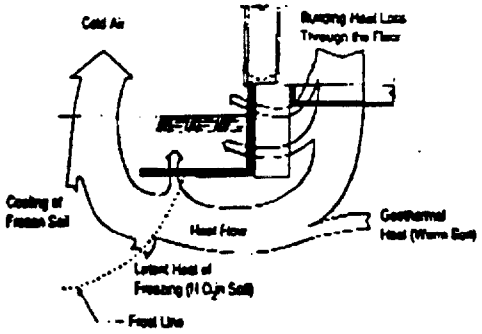
# FACT SHEET

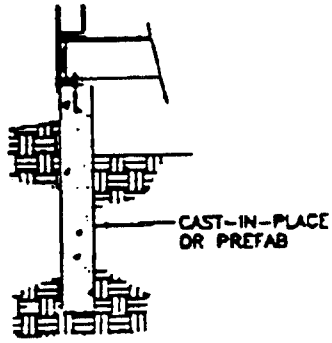
# SUCCESS STORY



TYPICAL DETAILS FOR WOOD FOUNDATION BASEMENT WALLS




FROST-PROTECTED SHALLOW FOUNDATIONS




STEMWALL FOUNDATIONS

## ALTERNATIVE FOUNDATION SYSTEMS

The U.S. Department of Housing and Urban Development (HUD) in cooperation with private industry and other government agencies has throughout the years researched and developed several types of innovative foundation systems.

**The All-Weather Wood Foundation Systems (AWWFS)** was developed cooperatively by the American Wood Preservers Institute (AWPI), the U.S. Forest Service (USFS), the National Forest Products Association (NFPA), the National Association of Home Builders, Research Center (NAHB-RC) and HUD.

It consists of a structural, pressure preservatively treated, wood foundation (see graphic) enclosing habitable or usable spaces located below grade and adequately dampproofed in accordance with applicable technical provisions. The AWWFS is part of the One and Two Family Dwelling Code under Section R-304.6. The AWWFS has been widely used throughout the U.S. for several years.

**Frost Protected Shallow Foundations (FPSF)**, researched and demonstrated by HUD and the NAHB-RC, is a slab on grade foundation (see graphic) that can reduce housing construction costs. Specifically, it's a frost-protected shallow foundations for slab-on-grade construction, a practical alternative in regions where more costly deep foundation construction methods are used. Foundations as shallow as 16 inches can be constructed in the most severe U.S. climates. The NAHB-RC developed a preliminary guide, based on past experience of European designs, to assist builders and others in constructing a FPSF.

**Stemwall Foundations (SF)**, a type of foundation (see graphic) that eliminates the need for separate spread footings and thus reduces labor and material costs. SF bear directly on the soil and are constructed to transfer the life and dead design loads directly into the soil. Given that current building codes do not provide prescriptive design methods for SF, design tables were developed by NAHB-RC to advanced the use of the SF.

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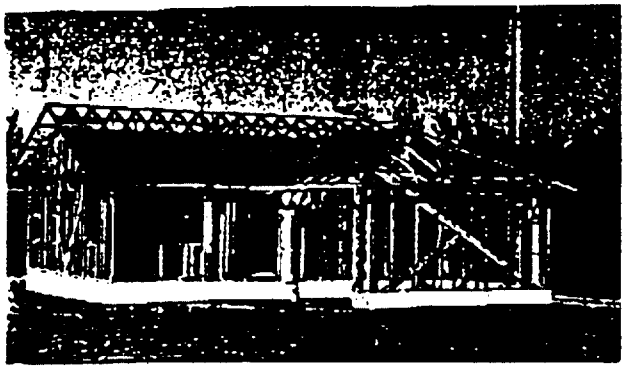


*HUD demonstration/test home is part of AISI/NAHB/HUD cooperative agreement to research steel and develop prescriptive building methods.*

# FACT SHEET

# SUCCESS STORY

In 1993 a cooperative agreement between the American Iron and Steel Institute (AISI), the National Association of Home Builder, Reserch Center (NAHB-RC) and HUD was agreed upon to research steel and develop prescriptive building methods. A demonstration home was built to evaluate different attachment methods for different sheathing materials, and evaluate alternative details (e.g. headers, truss connections, etc.).

Although light weight steel studs, originally developed in the 1960s for the residential market, have been widely accepted and successfully used for commercial construction for almost three decades, they did not catch on for use in residential framing until the 1990s.

In the 1970s and 1980s most builders felt no reason to change from wood, which was plentiful and inexpensive, to steel framing where fastening techniques were cumbersome, special tool were needed, and nuts and bolts required drilling and welding. In addition, builder knew residential carpenters were unfamiliar with this type construction.

In the early 1990s with a decline of lumber availability from the Pacific Northwest, where 30 percent of the U.S. lumber was produced, a change started to take place in the residential housing industry. Where as in 1992, 500 homes in the United States were built with steel framing; by 1994, 35,000 homes were framed in steel.

To help with the standardization of steel framing design, in 1991 the AISI published a manual for architects, engineers, builders and code officials that includes fastener information, construction guidelines, a thermal design guide, and standard details for wall, floors and roof systems.

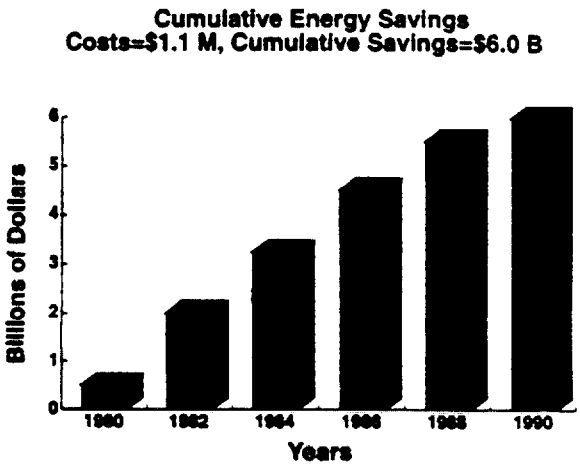
The cooperative agreement between AISI, NAHB-RF and HUD created standard sections and load span tables to introduce into the model building codes. As these standards are approved by the model codes this year, steel framed homes will be designed and built using codes similar to the ones being presently used for wood framed homes. This will provide greater flexibility and efficiency, an environmental and functional alternative to wood framing, and an additional choice in today's building market.

# Success Story

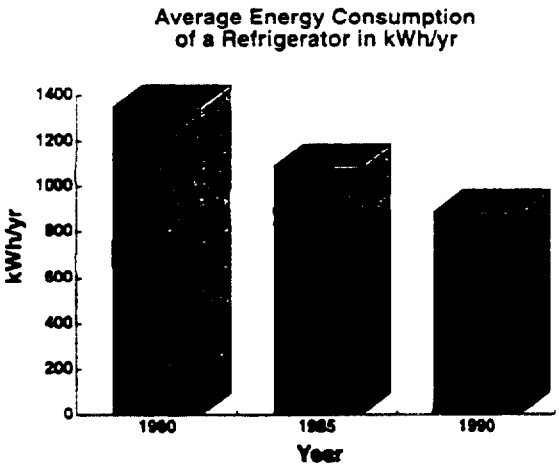
Office of Energy Efficiency and Renewable Energy

# High-Efficiency Refrigerator Compressor

From 1978 through 1980, Oak Ridge National Laboratory participated in a research project for the U.S. Department of Energy (DOE) with Columbus Products Company. The project was to develop a high-efficiency (energy efficiency ratio, or EER, of 5.0) compressor for household refrigerators. By making design changes to the motor, suction muffler, and compressor valve assembly and piston, Columbus Products achieved a 44% improvement over the compressor technology used in refrigerators at the time (EER 3.5).




The resulting technology was incorporated into a product line manufactured by Greenville Products Company (Kelvinator) of Grand Rapids, Michigan, which produced and sold the compressors through the mid-1980's. The technology was then transferred to Americold Compressor Company of Cullman, Alabama. Americold continued improving compressor designs on their own through the 1980's and 1990's and have exceeded the performance standard set by the DOE-supported development. They now market compressors with EERs of 5.2–5.5 and are developing a new line with EERs in excess of 6.0. Americold is the industry leader in high-efficiency compressors for refrigerators and freezers, manufacturing over 4 million per year.




The availability of high-efficiency compressors was a major reason that refrigerator energy use (on shipment-weighted-average basis) dropped from about 1500 kWh/yr prior to 1978 to about 900 kWh/yr in 1990. New refrigerators sold between 1980 and 1990, produced at an average rate of about 6.25 million units/yr, would have consumed 6.5 quads of energy without efficiency improvements. By incorporating energy efficiency into the refrigerator, 150 billion kWh or 1.7 quads of cumulative energy have been saved. Assuming that improved compressors account for about half of this, approximately $6 billion (at $0.08/kWh), in energy cost savings can be attributed to their use. Total DOE investment was about $1.1 million, resulting in a benefit/cost ratio of over 5400:1.

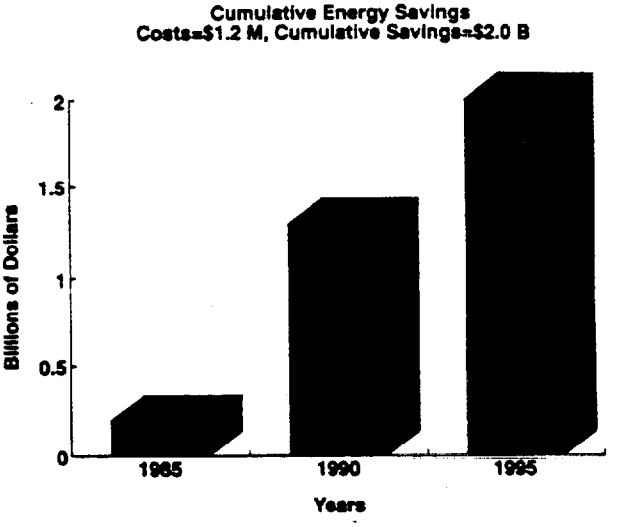
*Sources:*
"Energy-Use Data," Association of Home Appliance Manufacturers, August, 1992.
"Core Databook," U.S. Department of Energy, Office of Building Technologies, June 24, 1994, page 5-17.
Staelin, R., and Redinger, R. P., "Research and Development of Energy-Efficient Appliance Motor-Compressors, Vol. 2-Market Evaluation," ORNL/Sub/7229/2, December, 1980.
"Statistical Review," Appliance, 35th and 40th Annual Report, A Review of the Appliance Industry, 1988 and 1993.

# Success Story

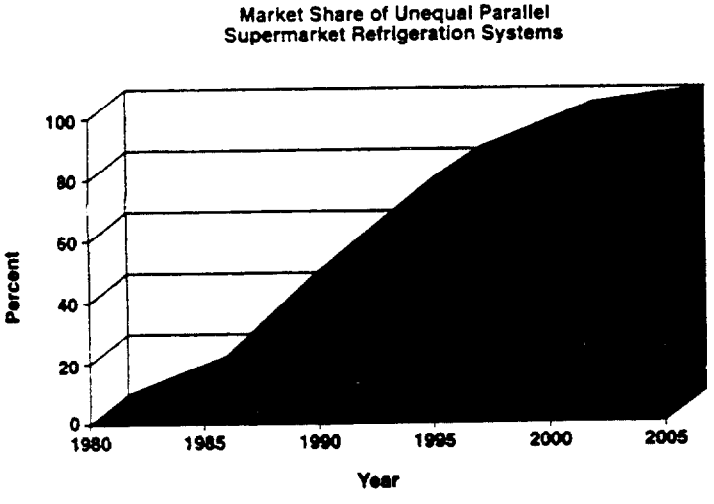
Office of Energy Efficiency and Renewable Energy

## Supermarket Refrigeration

The Oak Ridge National Laboratory (ORNL) and the U.S. Department of Energy (DOE) formed a partnership with industry to improve the efficiency of supermarket refrigeration systems. From 1980 through 1982, Foster-Miller Associates, Inc. (FMA), H. E. Butt Grocery Co., and Friedrich Commercial Refrigeration participated in the partnership.




The primary components of the improved system are an unequal parallel compressor rack system, a microprocessor controller that modulates the compressor capacity to meet the refrigeration load, and a condenser with floating head pressure control. Field trials of the advanced system at a supermarket in San Antonio, Texas, demonstrated a 16% energy savings over conventional systems. Subsequent to the DOE/ORNL work, Electric Power Research Institute (EPRI) sponsored studies with FMA and other manufacturers that resulted in further improvements in the compressor and control system. Supermarket energy use reductions of up to 35% were reported through use of the advanced systems. The control algorithms developed under the DOE/ORNL project provided the foundation for the microprocessor controls uniformly installed in new and retrofitted supermarket systems since the mid-1980's.




Supermarkets account for 4% of U.S. electricity consumption (1.1% of total energy consumption) and approximately 50% of supermarket energy is for refrigeration. Based on market share trends, 80% of supermarkets now use the advanced system. With an average of 30% energy savings per store, total cumulative energy savings is approximately 0.6 quads since market entry. Assuming that the control strategy developed by DOE/ORNL can take credit for half of the total savings, about 26 billion kWh or $2 billion at $0.08/kWh in energy and cost savings have been realized. The cost of the development program was approximately $1.2 million, resulting in a benefit/cost ratio exceeding 1600:1.

*Sources:*

Mahoney, Thomas, "Food Industry is Huge Market for Refrigeration Manufacturers," *The Air Conditioning, Heating and Refrigeration News*, Nov. 14, 1994, pages 38 and 40.

Refrigeration Systems Program Summary, U.S. Department of Energy, DOE/CH10093-120, Dec. 1991.

Walker, D.H., Burnett, M., and I. P. Krepchin, "Research and Development of Highly Energy-Efficient Supermarket Refrigeration Systems, Vol. 3-Evaluation of a Test System in a Supermarket," ORNL/Sub/80-61601/3, Dec. 1984.

# Success Story

Office of Energy Efficiency and Renewable Energy

# Heat Pump Design Model

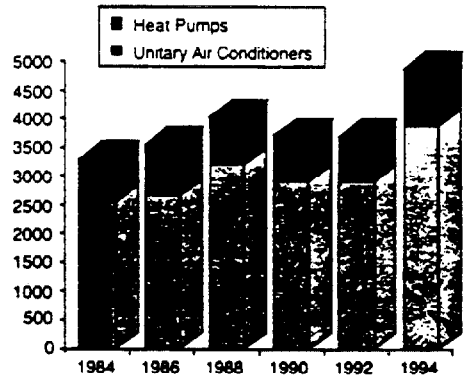
Through the Buildings Technology Center at Oak Ridge National Laboratory (ORNL), the Department of Energy has developed a computerized Heat Pump Design Model (HPDM), to assist industry in the design of new high efficiency heat pump and air-conditioning equipment. In the early 80's, ORNL conducted a pioneering study utilizing the HPDM which revealed that the efficiency of single-speed electric air-source heat pumps could be increased by more than 50% over current levels through the use of design optimization and higher efficiency components (i.e., compressors, fans, and heat exchangers). Total DOE investment in the early HPDM development and the efficiency study is estimated at about $750,000. It is estimated that this early work accelerated the market entry of high efficiency single-speed heat pumps and central air conditioners (CAC) by 5 years during the mid 80's. Using the following assumptions:

- average CAC and heat pump efficiency improvement of 30% over standard models;
- average total annual sales of 2 million CACs and 600,000 heat pumps (1981-1985);
- advanced units account for 10% of sales; and
- average annual heating/cooling loads of 8000 kWh/4000 kWh:

Cumulative savings over the five-year period of market acceleration are estimated to be over $170 million at $.08/kWh. Benefit-to-cost ratio for the DOE investment was over 225:1.

The HPDM comes in three versions: Mark III (single-speed, R-22), Mark IV (variable-speed, R-22), and Mark V-PUREZ (variable-speed, ozone-safe refrigerants and azeotropes). A new version, Mark VI-BLENDZ is being developed collaboratively with DuPont for use in system design with ozone-safe zeotropic refrigerants. The Mark III, Mark IV, and Mark V versions have been used extensively by the heat pump industry and provide manufacturers and designers with powerful simulation capabilities to aid in the development of advanced systems. The Mark V and Mark VI versions will aid manufacturers in the transition to ozone-safe refrigerants while maximizing the performance of future heat pump/CACs. Some examples of how the HPDM has been applied are listed below:

**U.S. Manufacturer Domestic Shipments of Unitary Air Conditioners and Heat Pumps 1984-1994* (in thousands)**




- **The Trane Company** coupled the model to an expert system to cut design time by 75% while improving design quality.
- **Allied Signal,** employed the tool in the evaluation and design of refrigerant alternatives and assisted ORNL in adding ozone-safe refrigerants to the Mark V version.
- **Gas Research Institute** adapted the model for design analysis of engine-driven systems.
- **Electric Power Research Institute** performed an assessment of variable-speed commercial heat pumps using the program.

Manufacturers using the HPDM in their product development represent more than one-third of the U.S. heat pump/CAC market.

*Sources:*

ORNL Reports: ORNL/CON-63, CON-80R1, TM-10192.
Statistical Profile of the Air Conditioning, Refrigeration, and Heating Industry, ARI, October, 1993 (Tables 17 & 18).
EPRI Heat Pump News Exchange, Vol. 2, No. 2, p. 2.
Spatz, M. HCFC-22 Alternative Refrigerants: Performance in Unitary Equipment, ASHRAE Trans. 1993, Vol. 99, Pt. 2.
*Statistical Profile of the Air Conditioning, Refrigeration, and Heating Industry, ARI, October, 1995 (Tables 17 & 19).

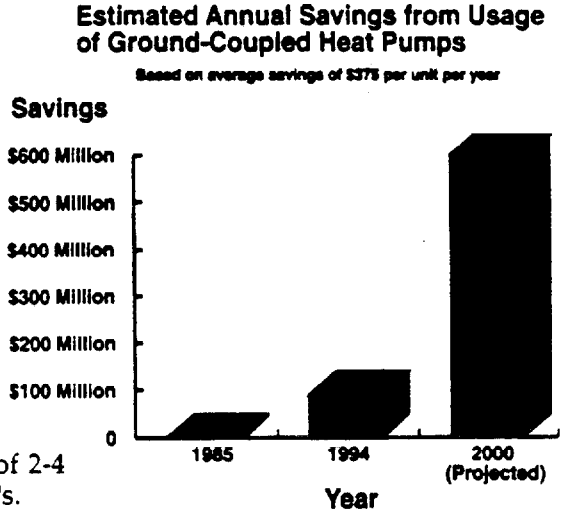
# Success Story

Office of Energy Efficiency
and Renewable Energy

## Ground-Coupled Heat Pumps

The Oak Ridge National Laboratory (ORNL) Buildings Technology Center (BTC) has conducted experimental and analytical studies of electric ground-coupled heat pumps (GCHPs) for the Department of Energy (DOE) Office of Building Technologies. GCHPs are more efficient than conventional electric air-source heat pumps because the ground generally stays warmer than the outdoor air in winter and cooler in summer. The primary focus of the research was to develop a technology base to enable design of ground-coupled (or "geothermal") heat pumps with lower cost to the consumer.

DOE research conducted at the BTC followed two paths. First, improved simulation models of the buried ground loop heat exchanger were developed. These were instrumental in developing improved loop design "rules of thumb" for northern climate areas that yield 40% to 50% shorter loops, hence, lower first-cost. Second, an overall system optimization analysis was undertaken to identify a "lowest life-cycle cost" system. It was estimated that improving the efficiency of the water-source heat pump (WSHP) could enable shortening the ground loop even further in some climates and soil conditions.




ClimateMaster Corporation built two prototype WSHPs with efficiencies more than 25% better than mid-80's state-of-the-art units. DOE and Niagara Mohawk Power Company co-funded a field validation study near Syracuse, New York, where energy savings of $350-$400 per year over conventional air-source heat pumps were demonstrated. Because of their shorter ground loops, the advanced GCHP systems had a payback of 2-4 years versus the 5-7 year payback on standard GCHPs.

The GCHP industry has grown considerably since this initial phase of the DOE research was completed. Several manufacturers now offer WSHPs with performance exceeding that of the prototype units developed under the DOE program. The National Rural Electric Cooperative Association, the Electric Power Research Institute, and the International Ground-Source Heat Pump Association have all worked with electric utilities and the industry to develop programs to reduce the ground loop cost to the consumer even further. One example is Public Service Company of Indiana's work with a housing developer to preinstall ground loops before subdivision construction started. This provided cost reductions of over $1000 per home.

The GCHP market has also grown. In 1985 approximately 5,000 units were being installed in residences per year. Currently in 1995, the market ranges from 40,000 to 50,000 units per year. A public/private partnership has formed with the goal of expanding shipments to 400,000 units per year by the year 2000. Assuming a linear growth of GCHP system sales and average unit savings of $375 per year, cumulative savings due to displacement of air-source heat pumps by GCHPs (1985-1994) is about $90 million. The estimated DOE R&D investment for this initial phase was $1.25 million, producing a benefit/cost ratio of 72:1.

*Sources:*

ORNL Report: ORNL/CON-193
Hackner, Hughes, O'Neil, "Design of ECHP Systems in Northern Climates," ASHRAE Trans. 1987, Vol. 93, Pt. 2, pp. 1858-1874.
Calm, J.M., ed., "Proceedings of Workshop on Ground-Source Heat Pumps," HPC-WR-2, 1987.
Video Presentation on Advanced GCHP System, Oklahoma State University Teleconference, September 1987.

**Office of Facilities Management Fact Sheet**

# Success Story

**Department of Veterans Affairs**

## Innovative Seismic Solution

### for VA Medical Center at Long Beach, California

The first medical facility in the United States to use seismic base isolation retrofit while still remaining fully in operation is now almost complete at the Department of Veterans Affairs Medical Center (VAMC) in Long Beach, California. This landmark project for the U.S. and the world represents a new direction by VA in its long history of seismic upgrading its existing facilities.

This 28-year old, 12-story, 355,000 square foot hospital is located on a particularly precarious site. After detailed investigation and analysis, the decision was made to correct the seismic deficiencies in the existing building and protect the medical center by using "base isolation" in the hospital's renovation. The project included inserting large, lead-core rubber pads into the concrete columns and walls in the basement of the hospital. Sections of the walls and columns above the foundations and below the first floor were cut away so isolators and sliders could be installed. By "isolating" the hospital footprint of 54,000 square feet from the ground, the amount of force and displacement transmitted into the structure by an earthquake is significantly reduced.

As of January 1996, all the 128 base isolators and 36 sliders were installed. The entire installation process took approximately one year. Sawcutting the concrete walls at the plane of isolation, the final step towards the transition of the hospital building from the "fixed" base structure to an "isolated" structure, was completed by mid-February 1996. The modification of adjacent connected buildings (the outpatient clinic and bridge) is also complete. There is now a 3'- 0" wide, 1,050-foot long "moat" around the entire perimeter of the hospital building, so it is free to move during a seismic event without any interference from adjacent structures. Also, all mechanical, electrical, and plumbing services crossing the plane of isolation were modified to allow movement of the isolated structure and enable the hospital to remain fully functioning after an earthquake.

The design team, VA's Office of Facilities Management (FM) and its consulting A/E, Albert C. Martin and Associates, engineered a comprehensive earthquake monitoring instrumentation package in collaboration with the United States Geological Survey (USGS), so the response of the building in future earthquakes might be evaluated. Despite the complexity of the intricate design and construction project, successful partnering among the design team with: the designer of the isolators, Dynamic Isolation Systems; the staff of the VAMC; the contractor, Dillingham Construction; and their base isolation subcontractor, Sheedy Drayage, the project will be completed on time, within budget, and with minimum impact to the existing operations of the Long Beach Medical Center.

**Project Benefits:**

- The hospital will withstand forces generated by seismic activity up to a maximum credible earthquake of 7.1 magnitude on the Newfront Englewood fault and 8.3 on the more distant San Andreas fault. The hospital is designed to remain fully in operation should seismic activity reach these limits;
- Seismic Base Isolation had a substantial economic advantage, a $6 million savings compared with other alternatives, considering the business disruption costs and the value of building contents;
- Construction time was reduced from other alternatives considered;

(please see reverse)

- There was no loss of functional space. In traditional shear wall strengthening, walls would have run through existing functional spaces, and considerable reconfiguration would have been required;
- The hospital has remained completely in operation throughout the entire retrofit process, without occupants being disturbed throughout the building by noise, vibration, debris and dust, as well as the phasing of renovation work in different areas, all of which would have been maximized by other methodologies for seismic upgrading; and
- There was no interruption of services to patients, human disruption or dislocation to patients or staff, nor business-loss economic costs.

In sum, Base Isolation provided this high level of safety for the hospital, its occupants, and maintained building functionality, economically, and without interruption.

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Office of Facilities Management Fact Sheet

# *Success in Federal Facilities Innovation*

Department of Veterans Affairs

# VA Hospital Building System

**ACHIEVEMENT:** The VA Hospital Building System (VAHBS) developed by the Department of Veterans Affairs (VA) has lessened the problems of obsolescence, satisfied the need for more flexible and efficient hospitals, shortened construction time, and controlled first and life-cycle costs in construction of large hospitals.

**PROBLEM, DESCRIPTION, AND SOLUTIONS:**. VA was faced with a pressing question: "How do you create flexible and efficient hospitals with longevity in an era when medical technology advances almost daily by leaps and bounds?" The goal was to address the problems that owners and managers of health care facilities often experience. These problems are: (1) rapid obsolescence of facilities; (2) objectionable long periods of time between the initial programming and occupancy of new hospitals; (3) rapid rising construction costs; and (4) unsatisfactory performance of building components; (5) the need to build more flexible and efficient hospitals; (6) the need to shorten construction time; and (7) the need to control first and life-cycle costs. A research study evolved from VA's own experience over a number of years with conventional and interstitial hospitals, each of which represented state-of-the-art hospital design at the time of its planning. What resulted was the VAHBS.

The VAHBS is a methodology for planning, designing, and constructing major new facilities and additions using planning modules as its basis. Each module contains a: functional level; service level; and, mechanical bay. These modules can be combined, both horizontally and vertically, as functionally required for specific projects. The design incorporates state-of-the-art technologies for buildings systems and energy conservation. All building systems in a new medical center, such as heating, ventilation, air conditioning systems, etc., are distributed in each module from the mechanical bay through the service level which is within interstitial space. These "service zones" are located above each occupied hospital floor and are divided into specific subzones for each service, offering significant advantages in life-cycle operating and maintenance costs.

**BENEFITS:** This approach to facility design offers numerous benefits to the entire structure. By creating separate repetitive modules and easily accessed dedicated areas, the efficiency of hospital resources are enhanced. Major benefits to the owner/user include: speedier planning, design, and construction time; control of construction bid costs and change orders; increased flexibility for future renovation, with decreased cost and minimal disruption to patient and staff areas; improved ease of maintenance; and lower life-cycle costs. Unlike conventional hospitals where access to the mechanical and electrical systems for maintenance and remodeling disrupts patient and work spaces, the new VA hospitals place these systems in an intermediate level, in interstitial space separated from the patient and working areas by a walk-on deck.

VA experience shows that the VAHBS is an invaluable system for large scale projects, such as full stand-alone replacement hospitals and major additions. While also shown useful in smaller scale projects, all the benefits may not be as fully realized. One of the special values of the system occurs when it is used in complex and dynamic areas such as diagnostic and treatment, as it allows maximum flexibility as medical care technology changes. VAHBS has been used very successfully in 15 completed projects. Additionally, 7 VAHBS projects are under construction or in design.

**COLLABORATIONS:** VAHBS was developed through a team effort among: VA's then Office of Construction staff; Stone, Marraccini, and Patterson; and Building Systems Development, and has been further individually adapted by each team developing each project.

**RESOURCES AND SCHEDULE:**. There has been much debate on the value and added benefits of the VA Hospital Building System. While the system requires a larger building envelope, higher floor-to-floor heights, increased quantities of materials and thus material costs, there is not universal understanding of construction cost impact. Construction of a VAHBS hospital requires less time, as many engineering trades can work together in the interstitial space, while finishing trades separately complete the functional floors. VA has conducted studies on the effectiveness and costs of the VAHBS; all studies have concluded that VAHBS is a superior, cost effective, and flexible system. Studies showed those VAHBS features which entail increases in initial construction material costs are offset by more efficient labor construction methods and consequent lower labor costs, and a shorter total construction time, so there is no net increase in the cost of the total building assembly. Knowledgeable building contractors cite actual significant cost and time savings with the system. An independent consultant stated:

> ***"The use of the Veterans Administration Hospital Building System has provided the Veterans Administration with a construction tool which has been shown to be cost effective in terms of reduced construction time and cost, fewer changes during construction, and a well organized coordinated physical plant that is easy to maintain, adaptable to changes, and energy efficient."***

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NIST

BUILDING AND FIRE RESEARCH LABORATORY

# Success Story

## EARTHQUAKE-RESISTANT PRECAST CONCRETE BUILDINGS

The ability of a structure to survive, or not survive, a large earthquake is in its details. The "holy grail" in the seismic design of buildings is the development of a structural system that allows speed of construction, component economy, and the ability to dissipate the energy of the earthquake while sustaining the least damage. Based on specially developed non-linear time history computer simulations backed by extensive laboratory tests, NIST researchers, with financial and technical support from private industry, have developed a new seismic framing system which uses precast concrete elements.

The innovative frame uses a hybrid system where high strength steel tendons are used to clamp the precast elements together and are designed to remain elastic throughout a maximum credible earthquake. Regular reinforcing bars or special stainless steel connectors are used to dissipate the earthquake energy. Tests have shown the dramatic capacity for the hybrid system to withstand large story displacements yet restore the structure in its initial position. The procedure is receiving high priority attention for inclusion in the 1997 building design codes and a test structure has been built in New York City using the design by Charles Pankow Buildings of Atadena, California. Pankow, one of the nation's largest building contractors, anticipates extensive use of the system once the design procedures, developed at NIST, are accepted by the codes.

Charles Pankow is placing high priority on this system as a potential replacement for cast in place moment frames while achieving the speed of erection and the moment resistance of steel frames. This technique will achieve the economies associated with mass fabrication.

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NIST

BUILDING AND FIRE RESEARCH LABORATORY

# Success Story

## DUCTILE STEEL MOMENT FRAMES AFTER NORTHRIDGE

Investigations conducted by NIST as well as others following the Northridge earthquake of January 17, 1994, revealed that over 200 steel frame buildings had suffered brittle failures in the welded beam-to-beam column moment connections. The damaged buildings ranged from four to 26 stories in height and were typically of modern construction. The discovery of such widespread and unexpected damage has caused considerable concern since welded steel moment frame construction is used commonly throughout the United States.

NIST, in cooperation with steel industry trade organizations and the SAC Joint Venture (SEAOC, ATC and CUREe) headquartered in Berkeley, California, convened a workshop to establish an agenda for addressing this critical problem. To characterize the extent of the problem and to provide information on which to guide the needed research, NIST conducted a survey of damaged steel buildings. The workshop resulted in a national plan to reduce the earthquake hazards of welded steel moment frame structures. Phase I has been completed and resulted in the publication, in August 1995, of Interim Guidelines for the Evaluation, Repair, Modifications and Design of Welded Steel Moment Frame Structures. Phase II is underway with NIST conducting forensic investigations, analytical studies and experimental research to establish guidelines for the repair and strengthening of welded steel moment frames.

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**Agency:** NSF

**Program Title:** Earthquake Hazard Mitigation /
Intelligent Systems for Seismic Protection of Buildings

**Products:** Proof of concept, design criteria and innovative hardware for the seismic isolation of buildings through rigorous analytical and experimental modelling. Technique is now an accepted alternate approach to seismic resistant design in which buildings are uncoupled from damaging ground motions. Application to several buildings in California are now complete. These include structures which require a higher level of performance than possible under conventional design procedures, as well as those older structures that cannot be economically retrofitted by conventional means.

**Goal Impacted:** Improved performance of buildings and contents during major earthqakes
Retrofit methodolgy for fragile historically important buildings

**Quantification of Impact:** Seismic isolation has given rise to a new industry in seismic protection. Consultants and isolation hardware manufacturers have become establishe dover the last five years. In addition to buildings, the technique is being applied to bridges and industrial equipment. Recent damging earthquakes in Los Angeles (1994) and Kobe (1995) indicate the potential impact that seismic isolation can have in reducing both direct and indirect losses due to earthquakes. For example the $55 million Teaching Hospital of the University of Southern California (USC) in Los Angeles is seismically isolated on 149 elastomeric isolators. Completed in 1989, the structure survived the Northridge earthquake of 1994 without either structural or non-structural damage. By comparison, the adjacent USC Medical Center (an 8-building complex) sustained an estimated $389 million loss.

Point of contact: Dr. William Anderson or Dr. S. C. Liu, NSF (703)306-1361

US Army Corps of Engineers

Construction Productivity Advancement Research (CPAR)

# Fact Sheet

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A Corps/Industry Partnership to Advance Construction Productivity and Reduce Costs

CP-1
May 95

## Mechatronically Assisted Mason's Aide (MAMA)

*Technology Challenge*

The masonry industry is comprised of a highly specialized group of people who perform a major part of the building construction in the United States. The repetitive, simultaneous bending and lifting to lay blocks has caused a high occurrence of on-the-job back injuries by masonry craftsmen, resulting in a high percentage of work related disabilities and early retirement of skilled workmen. The high incident rate of back injuries in work places across the U.S. has prompted the Occupational Health and Safety Administration to propose new guidelines for manual lifting that lowers allowable limits. The new limit is below what many common types of concrete and masonry unit blocks weigh. For these reasons, the masonry industry needs a device to assist in lifting and positioning heavy masonry units.

*Description of the Product*

The prototype Mechatronically Assisted Mason's Aide (MAMA) consists of a rail trolley system capable of being attached to standard, mast-type masonry scaffolding. The rails provide power and transverse mobility to a double jointed arm assembly suspended below it, much like a crane. A steel cable with a mechanical gripping device attached to the end provides the lifting power to pick up and place concrete masonry units.

*Status of Project*

A matrix analysis of the problem areas for masonry craftsmen as measured in terms of health and safety issues was conducted. Known technologies that might be applied to technologies already advanced to the application stage were then cross-referenced with recent scientific developments and theoretical technologies. A cost/benefit analysis was then used to assess which technologies showed the most likely quick paybacks and associated benefits due to enhanced productivity in the masonry construction industry. A prototype design was selected and evaluated in the laboratory using computer simulation. Final designs and specifications were then developed and a prototype constructed. Prototype field testing was conducted during the first quarter of FY95 at the job corps training center in Harpers Ferry, WV, leading to the identification and correction of control software deficiencies. The International Masonry Institute (IMI) is conducting further field testing and production engineering. Upon completion, the IMI will identify potential manufacturers for licensing MAMA. It is estimated that the first

production units will be available in January 1996.

***Partnering***

| | |
|---|---|
| Laboratory: | U.S. Army Construction Engineering Research Laboratories (USACERL), Champaign, IL |
| Industry Partner: | International Masonry Institute (IMI), Washington, DC |

***Cost Sharing***

The total cost for MAMA development was $528,700 with IMI providing 53% of the cost and USACERL the remaining 47%.

***Point of Contact***

IMI POC is Mr. Robert J. Beiner, PE, COMM 202-783-3908; or IMI, 823 15th Street, N.W., Washington, DC 20005.

USACERL POC is Mr. Orange S. Marshall, Jr., COMM 217-373-6766; toll-free 800-USA-CERL; or USACERL, ATTN: CECER-FL-M, P.O. Box 9005, Champaign, IL 61826-9005.

US Army Corps of Engineers

Construction Productivity Advancement Research (CPAR)

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A Corps/Industry Partnership to Advance Construction Productivity and Reduce Costs

Fact Sheet CP-13
17 January 1995

## Improving Construction Productivity through Integration of Real-Time Position Measurement with CAD/CAE

TECHNOLOGY CHALLENGE: The product being developed under this CPAR will improve the quality, speed, and accuracy of construction layout and generate in near real-time as-built digital files from digital as-designed files.

DESCRIPTION OF THE PRODUCT: The product consist of the development of a new laser-based positioning system capable of high accuracy, short-range three-dimensional measurements integrated with computer-aided design and drafting (CADD) technology. In addition, Global Positioning System (GPS) and total station technology were integrated to provide greater range and flexibility. Three-dimensional positional measurements with centimeter accuracy are currently possible. By integrating the positioning technology with CADD technology, the capability that results permits craftspeople, foremen, and on-site construction personnel to look at the CADD as-designed data on portable computers and instantly relate the graphic design to the construction environment. In addition, dimensional data on existing facilities can be rapidly collected for creation of accurate as-built drawings. The real-time recovery of as-built information will facilitate on-the-spot changes in components not yet installed to deal with the as-built environment. Upon completion of a project, an electronic CADD file of what was actually installed (as-builts) is available for the client. It is estimated that construction time will be reduced by 5%. The estimated cost of the laser-based positioning system (XPIRT), computer and software is $105,000. The estimated cost of the GPS positioning system (OTF), computer and software is $80,000.

STATUS OF PROJECT: The basic system has been completed and Bechtel Corporation fielded the first commercial version. The product was developed through an industry/government consortium. Initial research was directed toward defining data exchange protocols for GPS, total station technology and the XPIRT to provide real-time position measurements. A commercial version of the XPIRT and software modules to integrate GPS, total station and XPIRT technology to commercial CADD software was then developed. The integrated system was then demonstrated/field tested at a Bechtel construction site and a Corps of Engineers' project site. Both field demonstrations/tests were attended by potential users who provided valuable input on system refinements.

PARTNERING: The industry partner, Civil Engineering Research Foundation created an industry/academic consortium to accomplish this project which included Bechtel Corporation; Spatial Positioning System, Incorporated (SPSi); Jacobus Technology; and Intergraph Corporation. The participating laboratory was USAE Waterways Experiment Station (WES) with assistance from the Topographic Engineering Center (TEC).

COST SHARING: The total cost of the project was $550,000 with $250,000 as the Corps' share and $300,000 as the industry partner share.

POINT OF CONTACT: Further information can be obtained from Yvan J. Belivean, SPSi, Innovation Center, 1800 Kraft Drive, Blacksburg, VA 24060, 703-231-3145. The XPIRT system can be procured from SPSi. Total Stations and GPS hardware can be procured from many commercial manufactures. The GPS OTF software is available at no cost to the government from TEC. The laboratory point of contact is Harold L. Smith, USAE WES, ATTN: CEWES-IM-DA, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, 601-634-4190.

# Fact Sheet

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Fact Sheet CP-8
15 Mar 1996

Trenchless Construction: Evaluation of Methods and Materials to Install and Rehabilitate Underground Utilities

TECHNOLOGY CHALLENGE: America's underground infrastructure is an advanced stage of decay, especially in many of the older cities. Traditional open cut methods for replacing or rehabilitating sewer, water, gas, cable, and electric lines are disruptive to surface traffic, business, and other activities. In some cases, ground conditions make open cut construction extremely difficult and expensive. Trenchless technologies offer cots-effective replacement and rehabilitation of underground infrastructure with minimal disruption to surface activities. However, comprehensive guidelines and specifications that allow engineers, contractors, and owners to evaluate and select trenchless methods and equipment appropriate for their project requirements and ground conditions have not been available in the United States, limiting the acceptance and use of trenchless technology.

DESCRIPTION OF THE PRODUCT. The final product of this research and development is a set of guidelines for microtunneling, mini-horizontal directional drilling (HDD), and rehabilitation systems for existing pipelines. These guidelines are based on results of extensive field and laboratory tests, literature reviews, case studies, and an assessment of the state-of-practice of each industry segment. This work was awarded the Army Research and Development Achievement Award for 1995.

STATUS OF PROJECT. Extensive field and laboratory tests of microtunneling, mini-HDD, and rehabilitation systems have been completed, results evaluated, and reports published on the findings. State-of-the-art reviews have also been published. Guidelines for Trenchless Technology were published in July 1995. The guidelines were written in the same format as Corps of Engineers Guide Specifications, but with additional background information.

PARTNERING. Industry Partner: Trenchless Technology Center ; Louisiana Tech University; Ruston, Louisiana. Industry participants include over two dozen manufacturers, suppliers, and contractors in the microtunneling, mini-HDD, and rehabilitation industries, as well as the North American Society for Trenchless Technology. Laboratory Partner: US Army Engineer Waterways Experiment Station; 3909 Halls Ferry Road; Vicksburg, Mississippi 39180-6199.

COST SHARING. Total cost of the project was $1,560K with the industry partner providing over $960K and the Corps providing $600K.

POINT OF CONTACT. Dr. Leslie K. Guice; Head, Civil Engineering Department; Louisiana Tech University; Ruston, Louisiana; Phone: (318) 257-3176 and Mr. Robert D. Bennett (CEWES-GS-G); 3909 Halls Ferry Road; Vicksburg, Mississippi 39180-6199; Phone: (601) 634-3974; Fax: (601) 634-4656.

# Fact Sheet

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Fact Sheet CP-20
20 March 1996

TITLE. Fail-Safe Retrievable Microtunneling System Using Temporary Pipes and Reaming System for Critical Applications

TECHNOLOGY CHALLENGE. Conventional microtunneling systems are capable of installing a narrow range of pipe diameters for a given machine. In addition, if obstructions are encountered that prevent the machine from advancing, a rescue shaft is usually required to retrieve the machine or gain access to the face to remove the obstruction. The McLaughlin/Markham microtunneling system tested under this CPAR project provides innovative solutions to these limitations and offers intriguing possibilities for environmental remediation and other critical applications where failure cannot be tolerated.

DESCRIPTION OF THE PRODUCT. The product of this R&D will be documentation of performance and guidance for the use of a new and innovative microtunneling system that has been shown through field tests to offer reliability and retrievability under a variety of ground conditions, while offering the versatility to install a wide range of pipe diameters through the use of the reaming system. The system should provide enhanced reliability for critical applications, and greater versatility with regard to the range of pipe diameters that can be installed. These advantages are achieved through the use of temporary pipes and the reamer assembly. Potential drawbacks include the added capital and shipping costs, surface layout requirements and increased construction time associated with the use of these components.

STATUS OF PROJECT. Field tests have been successfully completed, and operational advantages have been demonstrated. The Super-Mini microtunneling machine was retracted 40 ft after an initial drive in flooded, running sand, while grouting the face to maintain stability with no significant ground settlement (<½ in.). The super-mini system then successfully drove 330 ft through five distinct soil conditions with the temporary pipes. The reamer assembly was then installed in place of the super-mini and the hole was successfully back-reamed from 26-in. to 36-in. diameter, while installing 33.5-in. OD concrete jacking pipe for the full 330 ft. Some needed improvements were noted during this phase of the test, specifically the need to improve the annular seal around the reamer head and the need to modify slurry injection points to enhance stability of the excavation face, especially in running sand or other potentially difficult ground conditions. In addition, the operation of the reamer assembly needs to be better integrated into the overall system so the operator has more precise control over the reamer, slurry injection, and retraction operations. The manufacturer is working out the details of these refinements. Preliminary results of these tests are available, and the final project report will be available by April 1996. The industry partner is actively promoting technology transfer and marketing the system.

PARTNERING.
Industry Partner: McLaughlin Microtunneling, Greenville, SC; Industry Participants: Markham, Chesterfield, England; SpunConcrete Pipe Ltd., England; Laxfield Corporation, Boston, MA; Baroid, Houston, TX.
Laboratory Partner: US Army Engineer Waterways Experiment Station

COST SHARING. $400K (est.) Industry Partner
$202K Corps
$602K Total

POINT OF CONTACT. Mr. Bill Gilman, President, McLaughlin Microtunneling, 2006 Perimeter Rd., Greenville, SC, 1-800-435-9340; and Mr. Robert D. Bennett, CEWES-GS-G, 3909 Halls Ferry Rd., Vicksburg, Mississippi 39180-6199, (601) 634-3974.

US Army Corps of Engineers

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A Corps/Industry Partnership to Advance Construction Productivity and Reduce Costs

Fact Sheet CP-9
January 1995

## *FALLING BEAM SOIL SAW, ADVANCED PROCESS FOR FORMING UNDERGROUND CUTOFF WALLS*

***Technology Challenge*** The SoilSaw™ Barrier System is a means of creating an underground "formed-in-place" barrier wall, without conventional excavation or back-filling, that meets permeability and strength specifications. Economics including high mobility costs might limit the technology to forming a wall greater than 1000 ft in length and 30 to 50 ft in depth, but costs would be site conditions and requirements specific. Large boulders and keying the wall into rock would also create a problem.

***Description*** The SoilSaw™ technology creates high-quality, "formed-in-place" barrier walls (presently 1 foot wide) by using high-energy jets on a reciprocating beam to liquify and mix the insitu soil with a permeability modifying reagent typically, but not limited to a bentonite or cement/bentonite slurry. Cutoff walls greater than 40 feet deep in soils which do not have excessive amounts of large rock or debris can be installed at rates of 100 square feet per minute and will be significantly more economical to produce. The narrow cut and rapid installation achieved with a Soil Saw can reduce costs per square foot of wall for a 40 ft deep wall by as much as 30% using conventional slurry mixes and further savings are estimated for an 80 to 100 ft deep wall due to time and equipment cost savings.

***Status*** The project is complete and a report is being published. A demonstration wall was installed at Sacramento, CA to verify width, depth, permeability, and strength specifications. Three other demo walls were visually monitored to verify improvements.

***Partnering*** Industry: Haliburton NUS Environmental; USACE Laboratory: USAE Waterways Experiment Station

**Cost Sharing** The total estimated cost of the project was $1,025k. The government's share of the cost was $275k.

**Point of Contact**

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# Appendix E: Construction Industry Collaborations Steering Committee

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